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MAY 1934

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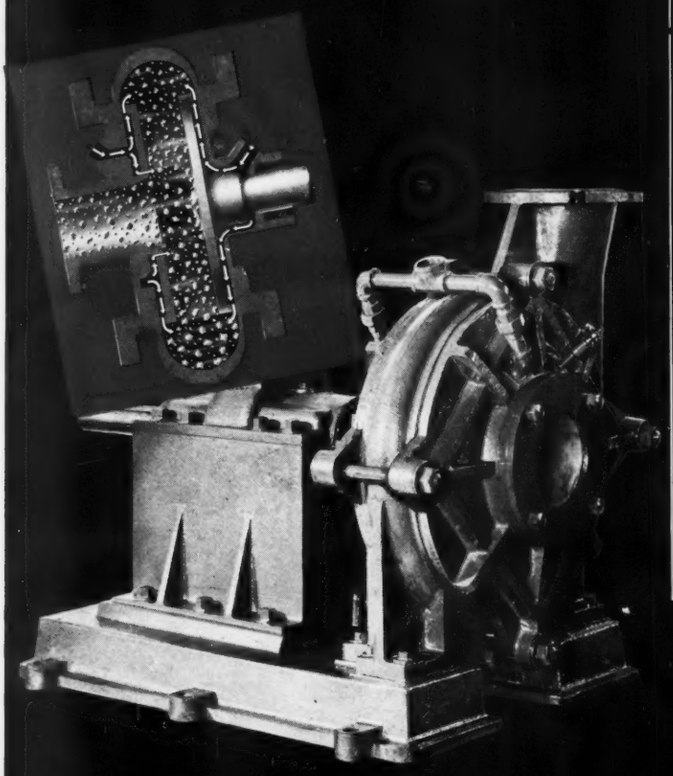

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Vice-President

CONTENTS FOR MAY 1934

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VOLUME 135 NUMBER 5

Editorials 193

Metallurgy at Falconbridge..*A. Gronningsater, J. R. Gill, R. C. Mott* 195

Deep Mine Hoisting.....*H. W. Dow* 200

A New Gravity Balance.....*Kenneth Hartley* 201

Beryl in the Black Hills.....*Francis Church Lincoln* 202

Bulkheading Abandoned Shafts.....*Charles F. Williams* 204

Styles in Salting.....*Marc Pawl* 206

Production Costs.....*H. D. Keiser* 207

Collection in Flotation.....*Guido R. M. del Giudice* 213

Sampling Mine Air for Dust.....*Arnold B. Black* 218

Trends and Developments in the Industry—
The Copper Code..... 220

Personal Notes—Comment—Criticism..... 234

Book Reviews 235

Industrial Progress 236

Market Data 238

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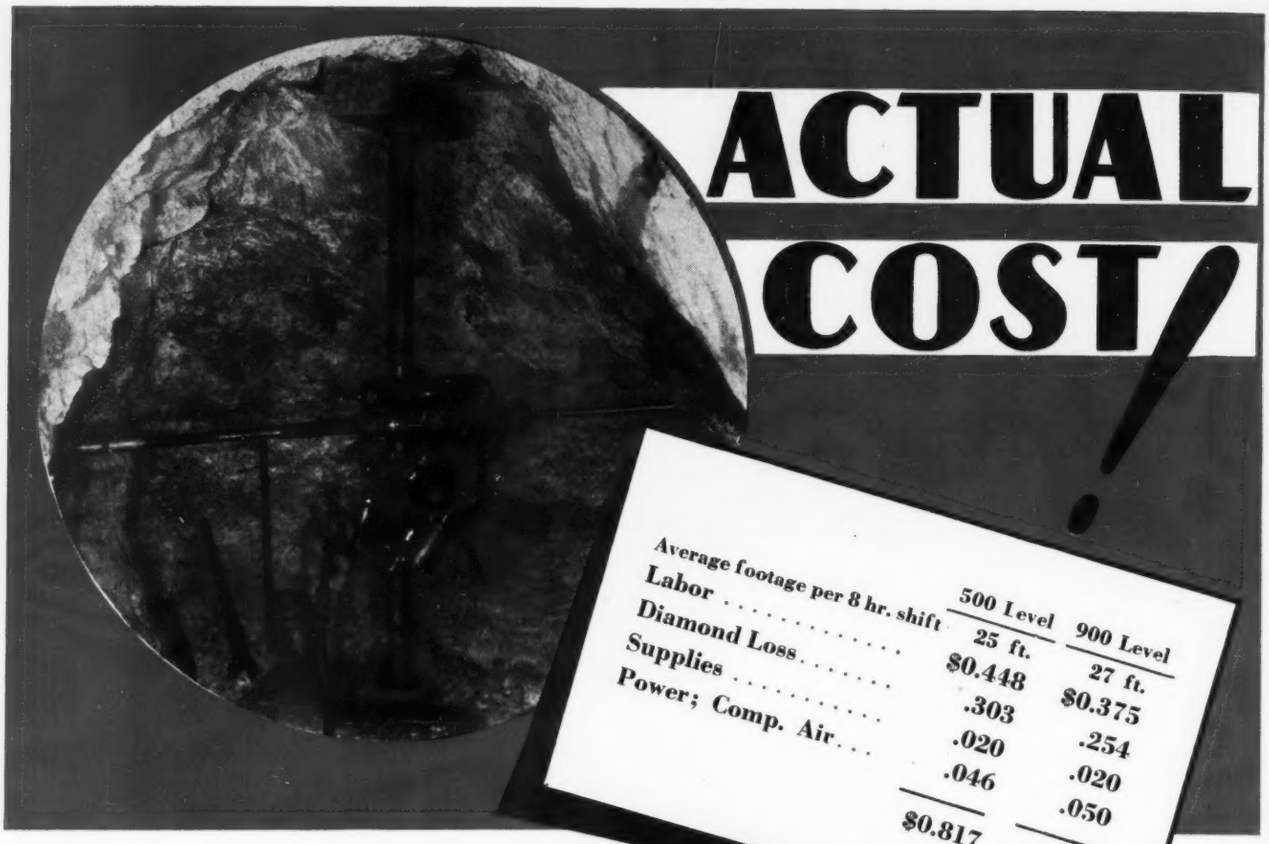

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Volume 135 MAY 1934 Number 5

Copper Industry Launched Under Code Regulation

WITH THE APPROVAL of its Code of Fair Competition on April 21, 1934, copper mining was the first major non-ferrous metal industry to be launched under the NRA. After seven months of patient negotiation, during which substantial agreement was reached on all provisions save those of marketing, the Administration imposed a sales plan on the industry in place of the latter's proposal to reach voluntary agreements relating to production, stocks, and prices. The Code is published in full in this issue. Its most important feature is Article VII—Marketing Provisions. It expires by limitation June 16, 1935.

Briefly, the Code relates only to duty-free copper for domestic consumption; and metal produced pursuant to the terms of the Code is designated "Blue Eagle Copper." Monthly sales quotas aggregating 20,500 tons and 9,500 tons are allocated to primary and secondary producers, respectively. There is to be no price fixing, except that a minimum price may be set in the event of destructive price cutting or excessive production. Existing stocks are practically frozen, and current production is to have first place in sales. No provision is made for production quotas or allocation of markets. A Sales Clearing Agent is established, with whom prices are to be filed by producers and to whom all sales of copper for domestic consumption are to be reported. Secondary producers are to endeavor to limit their intake in accordance with their sales quotas. A Code Authority of eleven members representing various factors in the industry is charged with administration and enforcement of the Code.

Benefits accruing to the industry under the Code will be found mainly in its stabilizing effect on production and marketing. By giving first place in sales to current production, it assures continuing operation of mines and mills, with all that is implied in employment and purchase of supplies and materials. It also minimizes the influence of surplus stocks on the market. Furthermore, the export market is still open to domestic producers and copper may be sold therein without regard to the provisions of the Code.

The Code Authority is confronted with knotty problems and great responsibilities, and on its wisdom and sincerity of purpose depends in large measure the success of this attempt at self-regulation of the copper industry. The Code needs interpretation and calls for the promulgation of rules and regulations. Agreements must be negotiated with fabricators, particularly with those that are not subsidiaries of primary producers, persuading them to cooperate in this movement toward recovery by freezing their own stocks and buying a substantial percentage of their requirements from current production. Finally, there is the difficult problem of controlling secondary production. Despite the magnitude of its job, however, we feel confident that the Code Authority will meet the obligations of the Code and lead the industry to better days. If it doesn't, who will?

Economic Planning For the Mineral Industry

FOLLOWING CLOSELY on the approval of the Copper Code, an announcement of great significance to the mining industry was made in Washington on April 27. As part of the Administration's scheme of national planning the President has appointed a Planning Committee for Mineral Policy to study the mineral resources of the United States and their future relation to national welfare. Under the chairmanship of Secretary Ickes, the committee comprises representatives of nine governmental departments and bureaus interested in the conservation, development and use of our metallic and non-metallic minerals.

The inclusive character of the committee suggests two thoughts: First, the broad interest of the Government in the mineral industry is indicated by the number of agencies represented—Interior, Commerce, State and War departments, and several of their bureaus. Second, the Government's extensive interest in the mineral industry might be better served if it consolidated in a single agency the scattered efforts of several.

One of the first recommendations of the new committee might well be to centralize and correlate in a single bureau the mineral economic studies now being conducted by the Bureau of Mines, the Bureau of Foreign and Domestic Commerce, the U. S. Geological Survey, the Division of Planning and Research of the NRA, and others.

If our mineral resources are to be intelligently conserved, developed and used, some such central economic agency must do the planning. Not only are the elements of such an agency already in existence in Washington, but they are to be found nowhere else in the country. The recommendations of the Planning Committee will be awaited with interest by the mining industry.

Recovery of Fine Gold From Gravels

THE MOST SIGNIFICANT DEVELOPMENT of recent years in ore-dressing practice occurred only a month or so ago when Bulolo Gold Dredging, Ltd., announced the installation of two six-cell flotation machines on its recently completed No. 3 dredge as accessory equipment for the recovery of fine gold from the gravel the company is treating at its property in New Guinea. This equipment, as described and illustrated in the news columns of the March number, was adopted following experimental investigations conducted on the dredge. It is employed in conjunction with jigs, a tube mill, and an impact amalgamator. Similar methods of treatment are to be used on the company's No. 4 dredge, now under construction.

Undoubtedly placer miners, hydraulic operators, and dredging interests have, as a group, been backward in applying the refinements of modern metallurgical practice to the treatment of their ores. One investigator even goes so far as to claim that the recovery per cubic yard of material treated in such operations can be increased from 10 to 200 per cent by saving the flour gold commonly sent to waste. Dredge recoveries, he contends, can be raised from the current 60 to 75 per cent to 90 or possibly 98 per cent.

Precious Metal Prices Make the Past Live Again

IN SPITE OF STREAM-LINED ZEPHYR TRAINS and airflow, knee-action automobiles, and all that comprises current technological advance, the past has a habit of persistently intruding itself in man's thoughts. As a group, the mining fraternity probably enjoys to a far greater degree than most of their professional brethren the fascination that the past has to offer. Explanation of this trait is not difficult; the historical element is an important factor in the practice of the profession; in fact, the success of any mining operation is usually dependent on the unraveling of an extended "history," the geology of the property. A lively interest in historical association and an approach toward current problems that includes an eye to the past are therefore natural attitudes on the part of the mining engineer.

The marked attention that higher prices for gold and silver are directing to mining activity of yesteryears cannot fail to attract the notice of mining men. In the preceding issue, for instance, an item in the news section recorded an effort to revive the old camp of Aurora, Nevada, where Mark Twain tried his luck in the 'sixties. Incidentally, one of the best accounts of those days and the Comstock boom that has yet been published is presented in a new volume, "The Saga of the Comstock Lode," by George D. Lyman, a brief reference to which work appears on the book review page in this issue. In the news section of this issue are illustrations featuring the return of gold placer operations in Damphool Gulch of Bingham Canyon, where gold was panned in the 'sixties by soldiers from the command of General Patrick E. Connor, who had been sent to Utah to quell Indian disturbances.

Perhaps the most striking recent evidence of the mining fraternity's interest in historical associations was disclosed at the annual meeting of the Canadian Institute of Mining and Metallurgical Engineers, held last month at Quebec. No session at the meeting seemed to hold for those present the natural, wholehearted interest that was apparent in the symposium on prospecting, in the course of which the discoverers of the Dominion's leading mineral deposits related, one after another, the story of their individual discoveries. To have heard Ed Horne, Gilbert LaBine, and the others describe the endeavors that led to such important subsequent developments—their statements will live in the memories of those that heard them long after most of the other events of the meeting have been forgotten. Man is that kind of a creature.

Economic Honesty In Management

NEGLECTING FOR THE MOMENT any consideration of the feasibility of nation-wide economic planning, it seems likely that the impetus in that direction had its origin in a growing belief that business management has not always shown wise restraint in capital investment, production, and marketing. Abuses have followed inevitably in the wake of unsound economic policies, and have resulted in a cry for reform.

In this connection we offer a thought on sound business management, particularly in those industries based on science and engineering. The engineer must of necessity be honest in his technology. He deals with inexorable natural laws, and any attempt to deceive himself or others in their application can lead only to failure or disaster. In the realm of economics there are equally inflexible laws demanding intelligent recognition on the part of management. To deny them is to invite adversity. If management will be as honest with its economics as engineering is with its technology, a long step will have been taken toward business stability and prosperity.

In response to requests from readers we have resumed publication in this issue of a market review and price quotations for metallic and non-metallic ores and minerals. The information will be found on page 238.

Metallurgy at Falconbridge

The World's Newest Nickel-Copper Enterprise

A. Gronningsater
Consulting Metallurgist

J. R. Gill
Smelter Superintendent

R. C. Mott
Mill Superintendent

ABOUT 13 miles northeast of Sudbury, in Ontario, Canada, near the eastern extremity of the southern Nickel Range, are the mine and the smelter of Falconbridge Nickel Mines, Ltd., the latest addition to the producers in the Sudbury field. The history of the smelter dates back to the early part of 1930, and exploration work at the mine has been undertaken at various times as long ago as the first year of the present century.

Ore is hoisted in 2-ton cars and discharged by a rotary dump into a 150-ton receiving bin. In the crushing plant adjacent to the shafthouse the ore is crushed in two stages, a 24x36-in. Hadfield jaw crusher with 6-in. opening, followed by an 18x30-in. crusher of the same make, set at 4 in. All material below 1¾ in. is removed from the discharge of both crushers by vibrating screens, and then subjected to further screening, producing fines and so-called "raggings," while the oversize from the secondary crusher is passed over a Dings magnetic separator consisting of a short 30-in. steel belt running over a magnetic pulley. Here the heavy magnetic sulphides (pyrrhotite) which constitute the furnace ore are removed, and the reject is hand-picked on the belt and sent to the flotation plant. About 12-14 per cent of the ore hoisted is removed by hand-picking.

In this manner the ore from the rockhouse, about 780 tons per 24 hr., is divided into four grades: Fines, below ⅝ in. with about 40 per cent sulphides, totaling about 17 per cent of the tonnage, these being sintered with concentrate and flue dust before they are charged to the blast furnace; raggings, ⅝ to 1¾ in., also about 40 per cent sulphides, 15 per cent of the tonnage, used as converter flux; furnace ore, about 42 per cent of the total, coarse material with 55 per cent sulphides, suitable for direct furnace smelting; and flotation-plant feed, the leaner part of the coarse ore, 26 per cent of the total with 20 per cent sulphides.

A 2,100-ft. aërial tramway, with an hourly capacity of about 50 tons, made by A. Leschen & Sons Rope Company, takes the different products to the reduction plant. Bins have been provided at the terminal for furnace ore and raggings, while fines and mill feed are discharged through surge hoppers to belt conveyors for distribution to their respective treatment units. A system of three belt conveyors distributes the products.

The mill feed is taken on a 24-in. conveyor to the Symons cone crusher, and the fines are handled by an 18-in. conveyor, 278 ft. long, discharging into a steel storage bin in the mill building. From this bin the fines are delivered by a short belt feeder to the conveyor carrying the feed to the sintering plant. With this bin installed in the mill building, no inconvenience is caused by frozen fines in winter.

Feed to the flotation plant is discharged from the bin at the terminal to a 250-ft. inclined, 24-in. conveyor, driven by a 7½-hp. motor at 100 ft. per minute, and delivering 50 tons per hour to a 4-ft. Symons cone crusher. Feed to this belt is regulated by a No. 3B Ross feeder equipped with 21-in. diameter drum and four 10-ft. chains, driven

by a sprocket and chain, at a speed of about 8 r.p.m., from a tail pulley of the conveyor. The crusher, which is driven by a 100-hp., 600-r.p.m. motor through an 8-belt Texrope drive, is equipped with a fine bowl and operated with ⅜-in. opening. Bowl and mantle liners are of manganese steel. The feed hopper and plate are of cast iron. Although the fines had been removed from the crusher feed, a great deal of dust was at first produced during crushing. This nuisance has been overcome by installing combination air-and-water sprays in the feed hopper and in the discharge chute. It is proposed to install screening equipment in closed circuit with the cone crusher, to remove oversize material from the ball-mill feed, and thus to improve the grinding capacity. The crusher is housed in a steel structure, sheeted with Robertson "protected" metal, adjacent to the mill building.

Crusher discharge is taken to a Link-Belt self-loading elevator by an 18-in. inclined belt conveyor, driven at 200 ft. per minute by a 3-hp., 870-r.p.m. motor. The elevator has 93 16x8x12½-in. overlapping buckets. It is driven by a 7½-hp., 870-r.p.m. motor at 145 ft. per minute and delivers the crushed material to mill storage. A differential brake prevents spills in case of power failure.

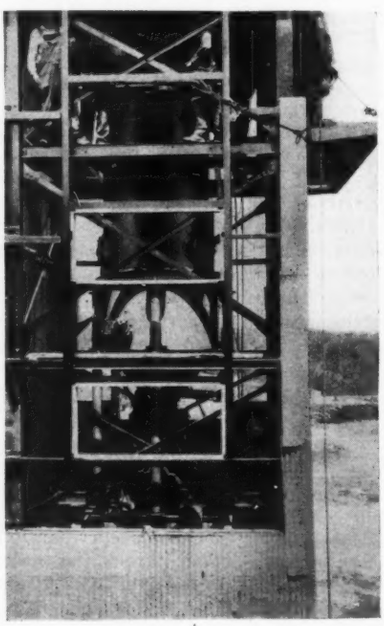
The mill building proper, containing grinding, flotation, and dewatering equipment, is of steel and tile construction, with Haydite roofing. It covers 7,100 sq.ft. An increase in tonnage up to 500 tons per 24 hr. is possible by adding space for grinding equipment only.

Grinding is done in an 8 ft. by 36-in. Hardinge ball mill, in closed circuit with a Denver unit flotation cell and a 6x25-ft. Model F Dorr classifier, operating at 24 r.p.m. at a slope of 3 in. per foot, and actuated by a 5-hp. motor with a V-belt drive. The mill bin discharges to a No. 5B Hardinge constant-weight feeder, the belt of which is driven by a ¼-hp. master geared motor. This feeder has given excellent results, the maximum variation in feed rate being about 2 per cent. It has a Mercoid switch, which may be connected with a stop light or a warning bell. An 18-in. belt conveyor, driven by a 2-hp., 870-r.p.m. motor, feeds the ball mill. The latter runs at 22 r.p.m. and has a drive unit consisting of a 150-hp., 700-r.p.m. motor, a 15-belt Texrope drive, sheaves, 6-in. pinion shaft, and cut-steel gears. It has a combination drum and scoop feeder, fitted with cast-iron wearing parts, and wedge-bar manganese steel liners. The discharge is equipped with a 4x4-mesh cylindrical screen. A ball load of about 16 tons is used, 4- and 5-in. forged steel balls being added daily in the ratio of 2:1. For 1933 the ball consumption was 2.6 lb. per ton. No data on liner wear are yet available.

Screen oversize is laundered directly to the classifier, and the undersize discharges by gravity into a Denver all-steel unit cell, having a Denver low-head shaft assembly and driven by a 10-hp. motor and V-belt drive. Tailings are discharged directly into the classifier, and the froth flows to the concentrate sump, whence it is pumped to the thickener. On account of the launder arrangement and the classifier density, the pulp dilution of the unit cell is limited to 65 per cent solids. Agitation of this heavy, coarse pulp (minus 4 mesh) requires high power and involves heavy replacement charges, but the results obtained justify the added expense. Under normal operating conditions, 60-70 per cent of the copper and about 40 per cent of the nickel are recovered from the grinding circuit. The comparatively rich concentrate is coarser than the main concentrate produced. This improves dewatering conditions. Some of the data relating to the grinding are compiled in Table I, from which one may note that the classifier overflow going to the flotation cells is comparatively coarse.

Dust-collecting station

Dust-collecting equipment housed in station shown at top of page



Classifier overflow (feed to flotation) and concentrate from the unit cell flow by gravity to a three-compartment sump. Material from the first compartment is pumped to a surge box on the main flotation floor by a direct-connected 3-in. Wilfley sand pump, with a 15-hp. motor, and concentrate from the third compartment is pumped directly to the Genter thickener by a 2-in. Wilfley pump, with 7½-hp. motor. The middle compartment is equipped with a 3-in. Wilfley pump, which serves as a spare for either of the other two pumps.

The main flotation section consists of two banks, each with eight 24-in. Denver cells, of the double-overflow type, steel frame and wood tank construction, fitted with 10-hp. motors and dual Texrope drives. Partitions and bottom wearing pans are of cast iron. Impellers and stationary hoods are rubber covered. Very little wear is evident after about a year's operation. The two banks of cells are connected in series, feed from the surge box flowing through cell No. 1, where a bulk concentrate is produced which is laundered to the concentrate sump and pumped to the thickening plant with the concentrate from the unit cell. Tailings go to cell No. 2, where a low-grade froth is produced which is laundered to the flotation feed sump for re-treatment, while the tailings are discharged by gravity to a pond about 350 ft. from the plant.

Average reagent consumption is approximately as follows: Soda ash, 1.5 lb. per ton of feed; coal tar, 0.05; coal-tar creosote, 0.15; cresylic acid, 0.04; potassium amyl xanthate, 0.07; pine oil, "Yarmor," 0.16; copper sulphate, 0.09 lb. Ten per cent soda solution is made in two 6x5-ft. fir tanks, connected to a 1-in. centrifugal pump for mixing and transferring the solution to the feed box of the ball mill. Constant rate of feed is attained by an adjustable siphon, mounted on a float.

Thickening is carried out in a 9-ft. Genter thickener equipped with sixteen five-tube frames and having a total filtering area of 450 sq.ft. Rake mechanism and timing device are operated with a 1½-hp. motor. Vacuum is carried at 20 in. and kick-back pressure at 25-30 lb., with 3 sec. kick-back at 1½-min. intervals. Two frames—that is, ten socks—are washed per shift. Addition of zinc sulphate to the Genter filter is made at the operator's discretion.

Genter filtrate is removed by a Con-

nersville rotary vacuum pump, connected by a short belt to a 5-hp., 870-r.p.m. motor. Density of thickener discharge is controlled by bushings. Thickened concentrate with 55-65 per cent solids discharges into a 14-ft. stock tank equipped with agitator mechanism. It is pumped by a 2-in. Wilfley, driven by a 10-hp. motor, to a 6-ft. six-leaf American filter, operated by a 2-hp. four-speed motor and James speed reducer. Normally, the slowest speed, one revolution in 5 min., is used, producing a filter cake with about 10 per cent moisture. Vacuum of about 25 in. is furnished by an 18x7-in. ER Ingersoll-Rand pump, Texrope driven by a 25-hp. motor, and the filtrate is pumped with a 2x1-in. Allis-Chalmers D O R centrifugal pump, direct-connected to a 2-hp., 1,150-r.p.m. motor. The filter cake drops directly on an 18-in. belt conveyor discharging to the conveyor feeding the sintering plant. Fines, concentrate, and flue dust are fed to this belt in the order given. This prevents wet concentrate from getting in contact with the belt, and keeps the flue dust sufficiently damp to prevent excessive dusting.

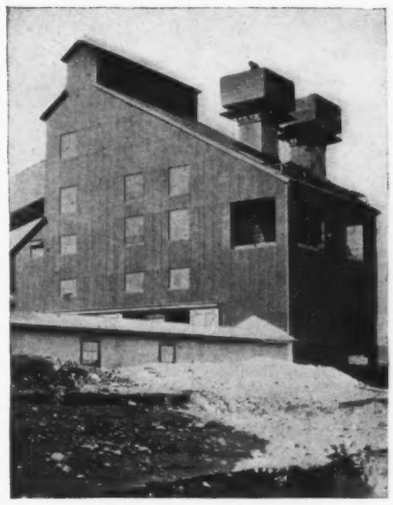
Fifteen men comprise the mill crew, including one crusher operator with helper, a sampler, three ball-mill operators, three flotation operators and three helpers, and three shift foremen. These men are also responsible for operating and maintaining the conveyor to the sintering plant, and, save for major repairs, for maintenance of mill equipment.

The sole purpose of flotation is to remove barren material. No selective action on the sulphides is sought. The composite assays for November, 1933, given in Table II, show how well this has been done. At that time the mill had been running for more than six months and the procedure had been well established. Recovery was 98.9 per cent of the copper and 94.3 per cent of the nickel, with a concentration ratio of 4:1. Total tonnage treated was 6,187 tons. Based on these assays, the calculated sulphide content of the tailings is 0.09 per cent chalcopyrite, 0.29 pentlandite, and 0.42 pyrrhotite, a total of 0.80 per cent, leaving 99.2 per cent barren rock.

Sintering equipment is housed in a five-story steel frame structure, 32x77 ft., with Robertson "protected" metal roofing and siding. It consists of two 42x264-in. standard Dwight-Lloyd machines with accessories, including bins for feed and discharge. The belt conveyor from the flotation plant which carries fines, concentrate, and flue dust discharges into a bin at the upper floor. On the fourth floor are drives for each unit and pug mills for mixing the feed, and the floor below is the operating floor. Concrete piers, carried up to the second floor, support the machines, and fan equipment, compressors, and oil tanks are installed on the ground floor.

Each machine, with feeder and pug mill, is driven by a 20-hp. motor, through a Reeves variable-speed regulator, whereby feeding and mixing are adjusted automatically to the speed of the machine, which may be varied between 8 and 24 in. per minute. Each machine is also equipped with a 72x6-in. fan, direct-connected to a 100-hp., 870-r.p.m. motor, capable of exhausting about 14,000 cu.ft. per minute. An independent air supply for the oil burners is provided by a small 40-cu.ft. per minute compressor. Fuel oil is piped from a 10,000-gal. storage tank to two 80-gal. tanks in the sintering plant.

A sintering charge is made up from 66 per cent fines, 27 per cent concentrate, and 7 per cent flue dust. Addition of water is rarely required, as the concentrate generally contains sufficient moisture. Reduction in sulphur from about 19.5 to 10.5 per cent is attained, with about 0.4 gal. of oil per ton of sinter. No provision is made for returning any of the sintered material to the feed, as this is not considered necessary under present conditions. Each pallet has three grates, and the average replacement has been one grate per 150 tons of sinter. Different types of grate bars have been tried out, and much better results are expected with the type now in use.



Sintering plant, exterior

As the discharged sinter is not quenched, the roasting will continue if any quantity accumulates in the bin. With present blast-furnace requirements, no need of running the sintering machines at maximum capacity has arisen. An average rate of 4.35 tons of sinter per machine-hour is easily maintained. An operating crew consisting of three men per shift is used, with an extra man on day shift to attend to oiling and clean grates with a pneumatic chipping hammer.

The smelting plant is a steel frame building with "protected" metal sidings and roof, consisting of a 43x126-ft. furnace section, and a 43x196-ft. converter aisle, with a 26x72-ft. lean-to for the matte molds. A rectangular water-jacketed blast furnace, built by Allis-Chalmers, 50x180-in. at the tuyeres, is used for matte smelting. Only a single tier of water jackets is used, and they do not extend to the sole plate but rest on a brick-lined crucible, 2 ft. deep. To prevent, as far as possible, any warping of the jackets, which are 30 in. wide and 14 ft. long, they are made with unusually deep flanges. The fire sheet, of $\frac{5}{8}$-in. plate, is flanged 15 in., and the $\frac{3}{8}$-in. back sheet 9 in. This construction has proved successful, for the jackets are straight and true after four years' service.

A cast-iron breast jacket is used at the front of the furnace, with cast-in pipes for the circulation of cooling water. The spout is also cast iron, with cooling pipes, and is lined with chrome or magnesite brick. Cooling water is circulated through the jackets at a rate of 500 gal. per minute. The settler has a shell of $\frac{1}{2}$-in. steel plate, reinforced with heavy angles. It is 18 ft. in diameter and 5 ft. high, lined with chrome brick and equipped with three tap holes, with magnesite tapping blocks. Frequent renewal of these magnesite blocks is necessary on account of the corrosive nature of the low-grade matte.

Rocker-dump charge cars, hauled by a 4-ton storage-battery locomotive, run on 24-in. tracks under all bins. They are equipped with Timken bearings and have a capacity of 3,000 lb. of ore. All cars are weighed on a platform scale as they enter the furnace building.

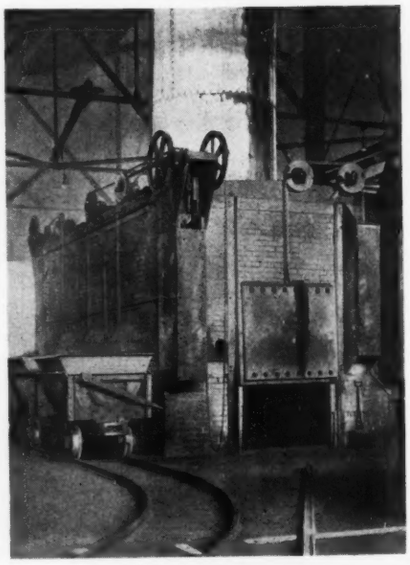
Blast-furnace slag, of which about 600 tons is produced per 24 hr., is granulated in a stream of water under a 50-ft. head, using 2,250 gal. of water per ton of slag. Formerly the granulated material was elevated to the slag dump by pumping, but this method presented difficulties. It is now run into a tank and dewatered by a drag conveyor which removes the solids as they settle and deposits them on an inclined 18-in. belt conveyor, the water flowing over weirs along the tank sides. The conveyor has a slope of 3 in. per foot and is at present 310 ft. long. To prevent difficulties during cold weather the entire equipment, including the conveyor, is completely housed in, and part of the warm water (120 deg. F.) overflowing the dewatering tank is pumped through pipes running through the conveyor gallery to furnish radiation. The water is then discharged at the top of the gallery, where it aids in spreading the slag from the head of the conveyor.

The converter plant has two Peirce-Smith converters, supplied by Allis-Chalmers, 13 ft. in diameter and 20 ft. long, with 26 $1\frac{1}{2}$-in. tuyeres, set 17 in. below the center line of the shell, which assures a high efficiency of the blast.

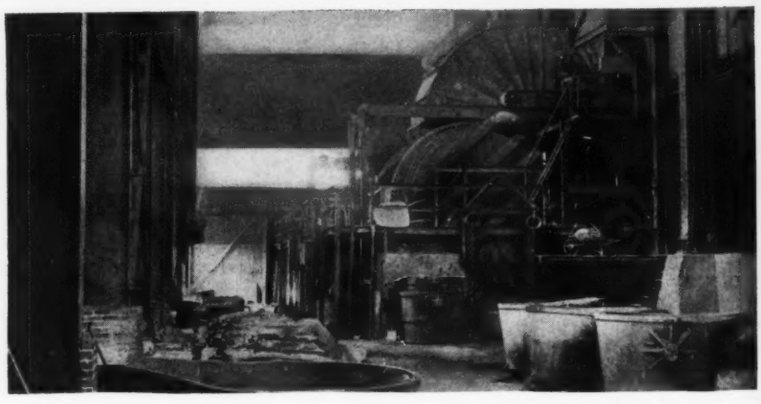
Each shell has two Garr silica guns. The lining, of magnesite brick, has to be repaired at the tuyere line after campaigns of four to six months. An Alliance Machine Company electric traveling crane with two 25-ton hooks serves the converter aisle. Matte and slag are handled in 75-cu.ft. cast-steel ladles. The finished converter matte is cast in iron molds, broken up, and crushed to about 1 in. in a 16x9½-in. jaw crusher. It is packed in 1,400-lb. barrels for shipment to the electrolytic refinery in Norway.

Blast-furnace and converter gases are passed through flues to a 40x80-ft. brick dust chamber, 22 ft. high, divided by a center partition into two sections which may be shut down separately for cleaning. The chamber is connected with a brick stack 175 ft. high with 12-ft. inside diameter. Both the furnace flue and the main flue are constructed of steel and are of the balloon type, with 57- and 73-sq.ft. cross areas, respectively. The converter flue is rectangular, 5½x7½ ft. Flue dust collected in flues and chamber amounts to 2 to 3 per cent of the ore treated. It is carried by a Dracco conveyor system to a storage bin, from which it is returned to the sintering plant. It is drawn through a pipe line to the collecting unit above the storage bin by a Nash pump and deposited in a number of bags, which are shaken at intervals, whereby the dust drops into a hopper and is discharged into the storage bin below through a series of three gates, so operated that vacuum is always maintained in the bag chamber. The system permits the handling and transportation of flue dust with total absence of loss and with a minimum of discomfort to the operator. Despite the abrasive nature of the material handled, maintenance of pipe lines and equipment is not a serious expense.

Air for the blast furnace is supplied by two single-stage centrifugal blowers, driven by 125-hp. induction motors, each having a capacity of 8,000 cu.ft. of 30-oz. air per minute and operating at 3,600 r.p.m. Single-stage centrifugal blowers are also used for both converters. Three blowers are installed, each with a capacity of 11,000 cu.ft. of 13-lb. air per minute, and driven by a 750-hp. synchronous motor, the speed being stepped up from 1,800 to 10,000 r.p.m. through a single set of gears. To our knowledge this is the only installation of single-stage centrifugal converter blowers. These blowers, which, like the blast-furnace blowers, are manufactured by the Elliot Company, are very efficient, and the cost is reasonable; with the exception of some initial difficulties, they have given satisfactory service. One blower furnishes sufficient air for a converter, and a separate main to each shell permits the units to be operated independently. The piping is so arranged that the third blower may serve either converter. Air at 100-lb. pressure is supplied to the various departments of the reduction plant from a 500-cu.ft. (per minute) rotary compressor. Direct current for crane and converter drives is supplied from a 125-kw. generator set in the power house. A storage-battery unit provides current to turn the converters off the tuyeres in case of sudden power failure. Electric power is received at 22,000 volts from the local system of the Hydro-Electric Commission and stepped down to the required voltage in outdoor transformer banks.



Blast furnace charging floor



The converter aisle

In the present smelting practice the blast-furnace charge consists of unroasted ore and sinter, with chilled converter slag and a small quantity of limestone as basic flux; the average charge is made up of 47 per cent ore, 27 per cent sinter, 23 per cent converter slag, and 3 per cent limestone, with coke consumption a little above 9 per cent on the charge. About 10 tons is charged at 20-min. intervals, giving a smelting rate of about 700 tons per 24 hr., or 11 to 12 tons per square foot of hearth area per 24 hr. Matte grade is about 14 per cent nickel plus copper. The following is a typical matte analysis: Nickel, 9.4 per cent; copper, 4.0; iron, 54.2; and sulphur, 24.7 per cent. A typical analysis of the slag taken at the point where it flows into the settler is as follows: Silica, 38.4 per cent; alumina, 10.1; lime, 5.6; magnesia, 3.7; and iron, 29.5 per cent. Settler slag for the same period was: Silica, 32.8 per cent; alumina, 8.55; lime, 4.3; magnesia, 3.1; iron, 36.8; nickel, 0.193; and copper, 0.102 per cent.

The low-grade blast-furnace matte is blown in the converters until the iron is almost completely eliminated. An initial charge of eight ladles of matte, or about 55 tons, is blown with two tons of flux to clean out the converter. After skimming, a ladle of matte is added, and the required quantity of flux, 5 to 6 tons, is introduced during the blow, which lasts 40 to 45 min. This is repeated until about 40 ladles have been added, whereupon the charge is finished by blowing the iron down to less than 0.2 per cent. Low-grade matte permits a high percentage of blowing time and good air efficiency. Flux is supplied in the form of ore (raggings) and gravel with 75 per cent silica, mixed in ratio of about 2:1. Converter operation is so arranged that 28 to 30 tons of finished matte is cast every day. The matte, which analyzes about 56 per cent nickel, 27 per cent copper, 16 per cent sulphur, and less than 0.2 per cent iron, is cast into molds, broken, and crushed for shipment. Converter slag contains 18 to 20 per cent silica and 48 to 50 per cent iron, with 3 to 4.5 per cent nickel plus copper.

Metallurgical treatment as outlined in the foregoing presents some unusual features. Flotation is used only for removing excess gangue from the smelting ore, with no thought of selective action on the sulphides, which under our conditions is not considered desirable; "scalping" of the bulk of the copper

would be of no advantage on account of our refining process; and if we attempted to carry pyrrhotite into the tailing the nickel loss would be too high. Our sole objective, therefore, is, as nearly as possible, to work on the principle of a self-fluxing ore. To attain this, only a certain part of the ore has to be floated. The resulting flowsheet is simple. Particularly clean concentrate is of no importance and conditions are therefore favorable for maintaining low tailing losses.

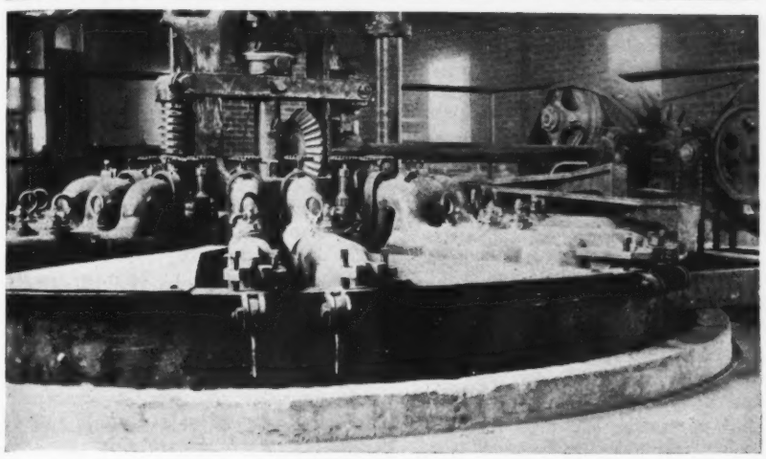
Roasting prior to smelting is not thought an advantage, as removal of sulphur involves a certain decrease in the heat value, which otherwise could be used in the converter. A lower sulphur content of the furnace charge also results in an increase in the nickel and copper content of the matte, which in turn has an adverse effect upon the slag losses. In our present operation a certain removal of sulphur takes place in the sintering operation, but this we consider a drawback.

With only part of the ore subjected to flotation and with no roasting operation, the bulk of the ore is left in lump form, suitable for treatment in a blast furnace. Compared with a combined roasting and reverberatory installation a blast furnace offers the advantage of a low capital cost, even if some sintering equipment is to be included. Another important consideration in our case is that the blast furnace operates just as efficiently on a small as on a large scale, which is not the case with a reverberatory furnace. Furthermore, a blast furnace gives lower slag losses than a reverberatory furnace, under the same conditions of matte and slag composition. These are the principal reasons for selecting a blast furnace for the matte smelting, despite the trend in favor of reverberatory smelting.

The higher fuel cost of a blast furnace is largely overcome by the treatment of a comparatively large tonnage of ore in the converter. At present 15 to 20 per cent of the total tonnage of ore going to the smelter is used as converter flux; that is, smelted without carbonaceous fuel. Actual fuel consumption thus averages a little over 10 per cent of the total ore smelted. Before sintering was introduced, with a lower grade matte, 25 per cent and sometimes even more of the total ore was smelted in the converters. The use of a self-fluxing ore also eliminates the expense of barren flux. With exception of a trifling tonnage of limestone charged to the blast furnace and a little siliceous gravel used on the converter no foreign flux is added.

Objection may be raised to the large tonnage of converter slag to be handled, but this really does not constitute a serious problem. About 40 per cent of the slag is chilled and used as basic flux on the blast furnace, whereby at the same time an extra good cleaning of this slag is effected. The remainder is cleaned by pouring it liquid into the blast-furnace settler. At Falconbridge, with the simplest kind of mechanical equipment, the handling of the chilled slag is done at a reasonable cost. On a large scale the cost could undoubtedly be further reduced by more extensive mechanization of the operation. To obtain a converter slag with the greatest possible fluxing value the silica content should be kept low—preferably not above 20 per cent. We have found it possible to operate with such a silica content, and even lower, with hardly any trouble from magnetite.

Neither does the handling of the large tonnage of low-grade blast-furnace matte involve any real difficulty. On account of its low melting point, it is, however, more overheated than a higher-grade matte and therefore somewhat harder on spouts, launders, settlers, and ladles. It has a much greater penetrating power and calls for the best and most suitable refractories.



Genter thickener

Fine-ore storage bin and flotation cells

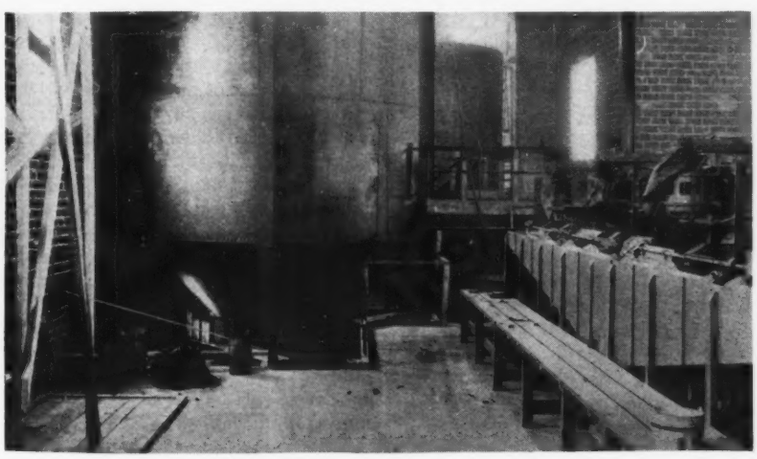


Table I—Results Obtained in Ball-Mill Grinding

	Crusher Discharge to Ball Mill 200–220		Ball Mill Discharge 72–74		Classifier Sand Return 700–850		Classifier Overflow 38–42	
Tons per 24 hr.								
Density range, per cent solids								
Screen tests	%	Cum. %	%	Cum. %	%	Cum. %	%	Cum. %
Plus 1 in.	1.1	.....	....	.....	....	.....	....	.....
Plus ¾ in.	3.3	4.4	....	.....	....	.....	....	.....
Plus ½ in.	51.2	55.6	....	.....	....	.....	....	.....
Plus ¼ in.	16.7	72.3	....	.....	....	.....	....	.....
Plus ⅛ in.	10.0	82.3	....	.....	....	.....	....	.....
Plus 1/16 in.	4.4	86.7	....	.....	....	.....	....	.....
Plus 20 mesh	6.9	93.6	10.8	.....	18.8	.....	....	.....
Plus 48 mesh	2.4	96.0	28.2	39.0	37.6	56.4	2.4	.....
Plus 65 mesh	0.6	96.6	13.3	52.3	11.8	68.2	6.1	8.5
Plus 100 mesh	0.9	97.5	13.8	66.1	9.7	77.9	12.1	20.6
Plus 150 mesh	0.6	98.1	7.3	73.4	5.0	82.9	11.0	31.6
Plus 200 mesh	0.6	98.7	7.5	80.9	3.5	86.4	11.9	43.5
Minus 200 mesh	1.3	100.0	19.1	100.0	13.6	100.0	56.5	100.0

Table II—Composite Analyses of Flotation Products

	Cu %	Ni %	Fe %	SiO_2 %	S %
Mill heads	1.12	0.85	17.4	39.1	7.6
Concentrate	4.43	3.18	39.0	12.1	28.2
Tailings	0.03	0.065	10.1	48.8	0.3

Deep Mine Hoisting

Problems Arising Between 4,000 And 7,000 Ft. Depth

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AS METAL MINES continue to operate, work must be conducted at greater and greater depth. At present, in North America, several mines have shafts more than 4,000 ft. deep, but none reaching 7,000 ft. On this account, I will confine myself mainly to the consideration of hoisting problems in vertical shafts between 4,000 and 7,000 ft. deep.

The hoisting or winding engine for working in such shafts is one of the first factors to receive attention. Several mines have incline shafts where the depth, measured along the incline, exceeds 7,000 ft. One shaft, No. 2 of the Quincy Mining Company, Hancock, Mich., is equipped with a winding engine capable of operating to 10,000 ft. deep measured on the incline. This hoist is now working from a depth of over 9,000 ft. Of course, in an incline shaft, the effective loads are less than the actual weight of ore, skip, and rope because of the incline, but the winding engine at the Quincy will wind 10,000 ft. of rope in a single layer. The drum is cylindro-conical—conical at both ends with a cylindrical section in the center 30 ft. in diameter. The small diameter of the cones is 16 ft., and the 10,000 ft. of rope in one layer is wound up one cone and across the cylindrical section. This instance is cited because for fifteen years this engine has been successfully winding a greater length of rope than would be required for the maximum depth of shaft considered in this article. No problem that is not already solved as far as the winding engine is concerned can present itself in shafts 4,000 to 7,000 ft. deep. All that would be required would be for the winding engine designers to make the machine a little stronger and provide a little more power to handle the greater loads which would be encountered in a vertical shaft.

The real problem in deep hoisting is to determine the load of ore to be hoisted per trip, the skip weight, and rope size. The best way to show this is to cite a concrete example.

One of the world's largest winding engines is being installed at the present time at the new Ross shaft of the Homestake Mining Company, at Lead, in South Dakota. This shaft is to be 5,400 ft. deep and vertical. The company will hoist 7 net tons of ore per trip in a steel skip weighing 12,500 lb. It will use $1\frac{7}{8}$-in. diameter steel hoisting rope, which has a weight of 30,400 lb. These loads give a static rope pull at the drums of 56,900 lb. This particular rope has an approximate breaking strength of 300,000 lb. and will therefore have a safety factor of 5.28, based on static conditions; that is, it is 5.28 times stronger than the load imposed.

The actual factor of safety to be used in choosing a rope is the subject of quite a bit of discussion. Agreement is general that it can safely be less in deep shafts than in shallow ones. For the former, the consensus of opinion is that it should never be less than 5. After a rope is placed in service it begins to deteriorate much faster at the end near the skip than at the other end near the drum, but of course the load imposed on the rope near the skip is much less, actually by the amount of the weight of the rope, than it is at the point adjacent to the drums. Some mining companies operating deep shafts have been sufficiently interested to take their discarded ropes, cut out sections near the skip, approximately at the center and from the end adjacent to the drums, and send them to government laboratories to be actually pulled apart. These results have shown that although the rope has reached a state where it is considered unsafe for further use, the weakest section near the skip still has a greater factor of safety at that point than a new rope will have at a point adjacent to the drum.

The Homestake's new hoist is equipped with two drums—one for each rope. Both are clutched to permit hoisting from any level in balance. The drums are cylindro-conical in section. The small end is 12 ft. in diameter and remains cylindrical until sufficient rope has been wound to cover the period of acceleration; then the rope winds up the cone to a diameter of 25 ft., where there is a second cylindrical section at this diameter which winds approximately 2,100 ft. of rope. This same set of drums could be used for a shaft 7,000 ft. in depth by turning the rope back at the outer flange and winding a second layer across the 25-ft. (diameter) cylindrical section. This is a practice quite generally followed in some of the deep mines of South Africa, but if the hoist were to be used on a 7,000-ft. vertical shaft, the size of rope would have to be increased to keep the factor of safety above 5.

Reduction of the skip weight might also be advisable, despite the extra expense. The all-steel skip, as already stated, will weigh 12,500 lb. If aluminum were used, as has already been done at several mines, the skip weight could probably be reduced to 8,000 lb. In such case, with 7 tons of ore, an 8,000-lb. skip and 2-in. rope weighing 44,100 lb., we would have a total rope pull of 66,100 lb., and the 2-in. rope, having an approximate breaking strength of 332,000 lb., would give a factor of safety of 5.02, which is very close to the limit. If a $2\frac{1}{4}$-in. rope, having an approximate breaking strength of 420,000 lb., were used, which would increase the rope weight to 56,000 lb. and give a total rope pull of 78,000 lb., it would provide a factor of safety of 5.25, and it is probably what would be selected.

From the foregoing one can see that although the weight of the skip was reduced 4,500 lb., the additional increase in depth of 1,600 ft. produced a set of conditions which required increasing the rope from $1\frac{7}{8}$-in. to $2\frac{1}{4}$-in. diameter. Somewhere between 7,000 and 10,000 ft. depth, a set of conditions would be reached where anything done to increase the rope diameter within reason would increase the weight so rapidly that the factor of safety could not be maintained above 5. In this case, one would have either to decrease the load of ore to be hoisted, and thus reduce the capacity of the shaft, or to resort to the use of tapered ropes. Such ropes have been made and used, but nowhere in this country up to the present time.

During the past half decade, most of the deeper mines of approximately 4,000 ft. in depth have purchased winding engines powered with electric motors, and, probably with the desire to reduce first cost, have installed these hoists to wind the rope in multiple layers, either two, three, or four. Experience has shown the impossibility of preventing the greatest rope deterioration from occurring at the point where the rope moves from the first to the second layer. In some cases, rope renewal costs have increased beyond expectations. Of course, the cost of ropes increases directly as their length. In the case of the Homestake company, this matter was thoroughly investigated. It was found that the interest on the added investment caused by having the hoists built to wind the rope in one layer was less per annum than what the rope renewal cost would be if the winding engine were built to wind the rope in multiple layers.

Practically all of the deep incline shafts have always been equipped with hoisting engines built for winding the rope in one layer. In the future one may expect that the mines operating between 4,000 and 7,000-ft. depths will give this matter careful consideration and probably wind likewise in one layer.

A New Gravity Balance

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An Instrument That Offers Advantages for Geophysical Prospecting

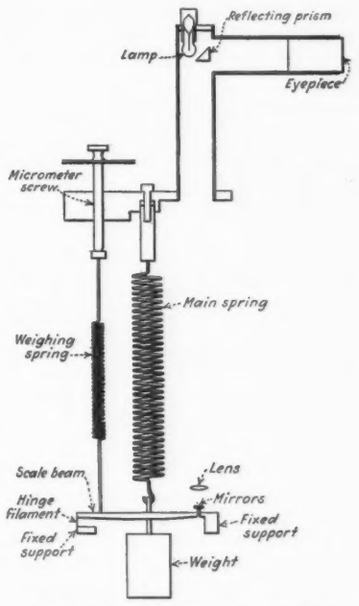
ALL GEOPHYSICAL METHODS of prospecting have a limiting depth beyond which the indications become increasingly indefinite and finally meaningless. The method which gives usable indications from the greatest depth is the measurement of the force of gravity; more accurately, the intensity of the gravitational field. The torsion balance measures the "gravity gradient"—that is, the rate of change of gravity with horizontal distance, and this indicates the presence of any mass of rock having a different density from the surrounding material; but the results are much less easily interpreted than measurements of the total force, particularly when the disturbing mass is more than a mile deep.

Intensity of the gravitational field may be measured either with the gravity balance or the pendulum. Recent improvements in pendulum apparatus have rendered it capable of sufficiently accurate measurements for this purpose, but the work is slow and expensive. The new gravity balance, here described, gives the same information at a fraction of the cost.

Measurement of gravity to one-tenth of 1 per cent by hanging a known weight from a calibrated spring and measuring the stretch of the spring is easy; but instead of one-tenth of 1 per cent we must have at least one ten-thousandth of 1 per cent, and preferably still better. Previous attempts to use springs for this purpose have failed because the designers of the instruments did not study the elastic properties of their materials with sufficient precision and did not understand the conditions that must be met to secure the degree of stability required for an instrument of this high sensitivity.

The Hartley gravity balance was designed so as to avoid some of the difficulties encountered in previous instruments and to control the others so that the instrumental errors will not exceed one part in ten million. The fundamental idea of the design is that if we can apply to a suspended mass an upward force almost, but not quite, equal to the pull of gravity, and maintain this force *constant,* it will be easy to measure changes in the small additional force required to hold the system in equilibrium. This will not give the total force of gravity but will measure the small changes that are due to differences in density of the material within two or three miles of the surface.

The instrument consists essentially of a weight and two springs, one very small and light, called the "weighing spring," which carries about one-thousandth of the load; and the other



Simplified diagram of essential parts of Hartley gravity balance. (*Physics*, March, 1932, page 124.)

of heavy wire carrying the remainder of the load and furnishing the upward force referred to, which must be kept constant to within one part in ten million. These two springs are attached to a very light weighing beam which is hinged at one end and carries two small mirrors at the other end. The heavy spring is attached to the center of the beam and the weight is suspended directly below, the weighing spring being attached between the center and the hinge. The tension in the weighing spring is controlled by a micrometer screw, and the spring is so adjusted that a stretch of one-thousandth of a millimeter produces a force at the center of the beam equal to two ten-millionths of the total force required to sustain the load in the zero position. In the present instrument the total load is about 150 grams; the beam is about 3 in. long and weighs 1.3 grams.

Location of the zero position to within one ten-millionth of the total stretch of the spring is necessary, in this case to within one hundred-thousandth of a millimeter. This is accomplished by the use of two small mirrors at the free end of the beam. Each mirror is carried on the tips of three very thin metal ribbons mounted vertically, two of them attached to a fixed support and the other attached to the beam. The arrangement of these ribbons is such that a vertical movement of the beam end causes the mirrors to rotate in opposite directions, each acting on the principle of the optical lever. The light from a small straight-filament lamp at the top of the instrument falls on the mirrors and is reflected through a lens to the observing telescope, where sharp images of the two reflections are seen side by side. When these two images form parts of a single straight line, the two mirrors must be in the same plane and the beam in the zero position. If the weight is displaced by one hundred-thousandth of a millimeter, the images as seen in the eyepiece are displaced from the straight line enough to be easily seen.

Obviously, this high amplification necessitates very perfect mechanical construction in every detail, particularly in the fine adjustments. There must be no loose pivots or knife edges. All moving parts are connected by elastic metal ribbons. The instrument is enclosed in an air-tight case, so that no change can occur in the density of the enclosed air which would alter the buoyant force on the weight. In addition, no change must take place in temperature during the time required for a complete series of observations, because the temperature effects are relatively large, and if the temperature is changed, several hours are required for the instrument to reach perfect equilibrium again. A portable thermostat has been devised that maintains the temperature constant to within one one-hundredth of a degree day and night while the instrument is in service.

The last and most serious difficulty is that of avoiding the effects of elastic hysteresis. By locking the weight and springs exactly in the zero position, the tension on the springs is never relaxed and no hysteresis effect occurs in them, but if the slightest displacement of the

weight laterally takes place, it will produce strains in the delicate ribbons supporting the beam and mirrors, and when the strain is released, they will not regain their normal condition immediately but may take a half hour or more to reach stable equilibrium. This difficulty has necessitated an elaborate locking mechanism that holds every part of the instrument rigidly in its normal position during transportation. Effect of vibration is reduced as far as possible by excessive air damping, and this has proved sufficient for all but very extreme conditions. The success of the instrument depends on the precise fulfillment of very exacting requirements in a multitude of details, which cannot be described here, but these things are essential to the maintenance of the necessary stability under field conditions. A fundamental patent was granted in 1932 and other patents, covering these details, are now pending.

The use of this gravity balance is very simple, but requires the same care and accuracy as in any other very precise measurement. After very precise leveling, the operator looks into the telescope and turns a small knob until the two lines of light come together; the graduated dial carried by the micrometer screw then indicates the value of gravity in millidynes above an arbitrary zero point. The instrument is then taken to another location, and the same procedure gives the value there. The difference between these two readings is the difference in gravity.

The balance has so far been used only for outlining salt domes in the Gulf Coast region, but several other uses readily suggest themselves. One must remember that, although the difference in density between rocksalt and limestone or sandstone is small, the volume of salt is very large, amounting to several cubic miles in a moderate-sized dome, so the detection of other materials will be practicable only when deposits are of considerable thickness.

BERYL

IN THE BLACK HILLS

Francis Church Lincoln

Professor of Mining
South Dakota State School of Mines,
Rapid City, S. D.

BERYL, at present the only commercial source of beryllium, occurs in many of the pegmatite dikes and knobs which intrude the Algonkian schists of the Black Hills of South Dakota, and is obtained from them mainly as a byproduct of mica, feldspar, and lithium mining. It has never been found distributed regularly throughout a pegmatite body, nor present in large proportion in any part of such a body, but always in irregular shoots of low beryl content. Known occurrences are listed in Table I, but a careful search would undoubtedly reveal many others. Beryl is commonly associated with quartz, microcline, albite, or amblygonite. Shoots of it frequently adjoin shoots of muscovite and occasionally overlap them.

The mineral, beryl, is a beryllium-aluminum silicate, the formula being $3BeO.Al_2O_3.6SiO_2$, and contains 14 per cent of beryllia (BeO) when pure, equivalent to 5.1 per cent of beryllium. Replacement by sodium, lithium, or caesium may reduce the latter to as low as 4 per cent. Some Black Hills beryls have beryllia contents of less than 10 per cent, due to replacements and inclusions, but others have contents exceeding 14 per cent. Common beryl usually occurs in irregularly terminated hexagonal crystals which range in size from mere threads to immense columns. In most cases, it is white or green in color, though at times it may be yellow, red, or blue. Sometimes it resembles quartz, from which it may be distinguished by its basal cleavage and greater hardness. The Black Hills beryl is usually white, but sometimes yellowish, reddish, or greenish. It is almost always translucent, although in a few instances transparent crystals have been found which approached gem quality.

Inasmuch as the beryl shoots in the Black Hills pegmatites rarely contain more than 1 to 2 per cent of beryl, it is usually necessary to mine 50 tons or more of dike material to get 1 ton of beryl. The highest price obtained for beryl in recent years was $55 and the present price f.o.b. Keystone is $35; so only in exceptional cases can the pegmatites be worked at a profit for beryl alone. Beryl has been shipped from all the mines in Table I characterized by the reference mark (*a*), and piles of sorted beryl or beryl-bearing dumps may be found upon most of the other properties listed. No accurate records have been kept of the beryl production, but approximate figures will be found in Table II.

As will be seen from Table II, the Peerless mica mine has been the largest beryl producer in the Black Hills. This mine is located on the outskirts of Keystone, in the southern Black Hills on a spur of the Burlington Route. It belongs to the Keystone Feldspar & Chemical Company, of which Ernest Reckitt, of Chicago, is president. The Peerless pegmatite is in the form of a great knob with an outer muscovite-bearing zone and shoots of muscovite penetrating the interior. Beryl occurs adjacent to the muscovite shoots. The mining methods employed at the Peerless have been described in these pages[1].

Second in importance as a beryl producer and the biggest shipper of the mineral in 1933 is the Ingersoll mine, 3 miles by road northwest of Keystone. It belongs to the Black Hills-Keystone Corporation, of which William K. Wallace, of New York, is president, and A. I. Johnson, of Keystone, resident manager. At the mine two pegmatite dikes, known as the Lower and Upper dikes, outcrop on a hillside. Both strike northeast, dip northwest, and are short and broad, with rounded terminations. Mining has been conducted at the lower or southwest ends of both dikes, the elevation of the open cut on the Lower Dike being 5,000 ft. and that on the Upper Dike being 5,140 ft. above sea level. A tunnel cuts the Upper Dike at a depth of 107 ft. below the open cut.

Beryl has been found at the Ingersoll in the open cuts on both dikes, the occurrences being similar. An outer muscovite-bearing zone, 5 to 10 ft. wide, is exposed in each cut, and immediately within this a beryl-bearing zone of similar width, while the interiors of the pegmatites are apparently free of beryl. The width of the Lower Dike in the open cut is 50 ft., and it is in this dike that the largest beryl crystals have been found. In 1916, a beryl crystal was exposed here which measured 44½ in. in diameter between opposite hexagonal faces[2]. This was the largest known until 1929, when a group of huge crystals was found at Albany, Maine, the largest of which was 4 ft. in diameter and 18 ft. long[3]. In 1933, however, a beryl crystal of twice this diameter, or 8 ft. between opposite hexagonal sides, was exposed in the open cut on the Lower Dike at the Ingersoll mine

[1]F. C. Lincoln: "Feldspar Mining: A New Industry in the Black Hills." *E. & M. J.*, Vol. 124, July 2, 1927.

[2]W. A. Waldschmidt: "The Largest Known Beryl Crystal." Pahasapa Quarterly, 9, Dec., 1919, pp. 11-16.

[3]H. S. Spencer: *E. & M. J.*, Vol. 128, Nov. 30, 1929, p. 858.

[4]V. Ziegler: "The Mineral Resources of the Harney Peak Pegmatites." *Min. & Sci. Press*, Vol. 108, 1914, pp. 604-8.

[5]F. L. Hess: "The Natural History of the Pegmatites." *E. & M. J.*, Vol. 120, Aug. 22, 1925, pp. 289-98.

Table I—Beryl Occurrences in the Black Hills

Southern Hills
Vicinity of Keystone
(a) Peerless Mica Mine
(a) Ingersoll Mine
(a) Sitting Bull Claim
(a) Hugo Feldspar Mine
(a) Etta Spodumene Mine
Dan Patch Claims
Granite Claims
Canfield Claims
Glendale Group
Hardesty Ranch
Hesnard Dike
Phyllis and Philip Claims
White Cap Mica Mine
Spokane Lead-Silver Mine
Vicinity of Custer
(a) Tin Mountain Mine
(a) Old Mike Mine
(a) Maywood Claim
Crown Mica Mine
New York Mica Mine
White Spar Mica Mine
Hitchcock Mica Mine
Climax Mica Mine
Custer Claim
Tiptop Claim
Sunnyside Claim
Royal Flush and Dubuque Claims
Michaud Claim
Gem Mica Claim
High Climb Claim
Vicinity of Pringle
(a) Beryl Lode
(a) Mountain Beryl Claim
Beecher Lode
Northern Hills
Nigger Hill District
Tinton Mine

(a) Beryl has been shipped from this property.

while mining beryl. The length of this crystal is not known, and can never be exactly determined, since a portion of it was mined before it was realized that the mass constituted a single immense crystal. An analysis made at the South Dakota State School of Mines showed that this big crystal contained 10.54 per cent beryllia. The shoot in which it occurs contains about 10 per cent beryl, an unusually high concentration.

The lithium minerals—amblygonite, lepidolite, and spodumene—are also found at the Ingersoll. These are more plentiful in the Upper Dike than in the Lower Dike. The Upper Dike is 85 ft. wide in the open cut, and the central portion inside the muscovite and beryl zones is composed mainly of quartz and microcline feldspar, but contains two chimney-like shoots rich in lithium minerals. Near the beryl zone is a shoot of lavender lepidolite, or lithia mica, 30 ft. long by 15 ft. wide, which has been cut in the tunnel 107 ft. below. Adjoining this chimney to the northeast is a 5x7-ft. chimney of amblygonite in quartz, which has not been cut by the tunnel. A shaft is being sunk upon the amblygonite shoot and the lithium ore taken out and shipped to Germany. Amblygonite has been shipped from this mine for years, and as early as 1914 the property was classed as an amblygonite mine[4]. Small shipments of lepidolite have also been made for years, the lithia mica being used for ornamental and experimental purposes rather than as an ore. Only a little spodumene has been found.

Small amounts of uraninite, or pitchblende, are also found in the Ingersoll. Calculations based on analyses of this uraninite give it an apparent age of about a billion and a half years and make it the oldest known uranium mineral. Columbite, an ore of columbium and tantalum, occurs here also, and numerous small shipments have been made. While commonly found in small tabular crystals, a large mass of columbite weighing nearly a ton was once discovered in the mine. In explanation of his theory of the formation of pegmatite, Frank L. Hess cited several interesting replacements which he observed in the Ingersoll mine[5]—one of which was albite replaced in part by columbite and cassiterite. Other minerals noted in the mine were apatite, black tourmaline, and green tourmaline, which approaches gem quality.

While commonly found in pegmatite, beryl also occurs in a number of granitic rocks and in some metamorphic rocks such as slate and mica schist. Outside of the Black Hills, the principal sources of the mineral, in the United States, are the mica and feldspar mines of New York, Maine, New Hampshire, and North Carolina. Deposits are also known in Alabama, California, Colorado, Connecticut, Georgia, Massachusetts, Nevada, New Mexico, Pennsylvania, South Carolina, Utah, Virginia, and Wyoming. Outside the United States, beryl is found in Canada, Mexico, Brazil, and Columbia; in England, Ireland, Norway, Bavaria, Austria, Spain, Portugal, Elba, and Russia; in Siberia, India, and Burma; in South West Africa, Namaqualand, Transvaal, and Madagascar; and in New South Wales.

Beryl is used in the manufacture of porcelain, and in Germany there is one firm which devotes its efforts to the production of beryllia for ceramic use. In the United States, beryllia has recently found commercial application as an electrical refractory, and the beryllium chemical industry, as distinguished from the metal industry, is undergoing

Largest known beryl crystal, 8 ft. in diameter. Dashes indicate the crystal outline.

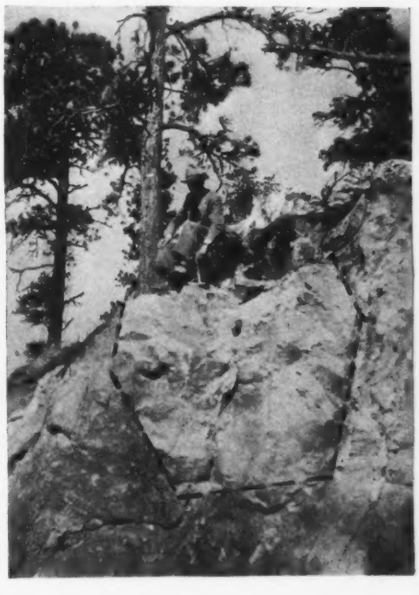


Table II—Beryl Production of the Black Hills

Year	Mine	Tonnage—Partial	Tonnage—Total	Valu
1914	Keystone District	....	6	$538
1915		....	0	....
1916		....	0	....
1917		....	0	....
1918	Peerless	....	3	270
1919	Ingersoll	....	3	180
1920		....	0	....
1921	Ingersoll	....	2	105
1922	Ingersoll	....	3	157
1923	Ingersoll	....	6½	330
1924		....	0	....
1925		....	0	....
1926	Peerless	25	..	....
	Ingersoll	½	25½	1,271
1927	Peerless	....	30	1,500
1928			0	....
1929	Peerless	170	..	....
	Tin Mountain	27	..	....
	Old Mike	22	..	....
	Maywood	3½	..	....
	Ingersoll	¼	222½	12,238
1930	Sitting Bull	3	..	....
	Mountain Beryl	3	..	....
	Beryl Lode	1	7	350
1931		....	0	....
1932		....	0	....
1933	Ingersoll	54½	..	....
	Peerless	25	..	....
	Hugo	4	83½	2,914
			391½	$19,853

rapid development. The Brush Beryllium Company, of Cleveland, has pioneered in this field and now manufactures seven varieties of beryllia and beryllium salts for commercial and experimental use. Another important use of beryl is as a precious stone. Emeralds, aquamarines, and gem beryls are transparent varieties of beryl. Nineteen minerals containing beryllium are known, but beryl is at present the only one used as an ore.

Beryllium is a steel-gray metal, harder than glass, about one-third lighter than aluminum and only slightly heavier than magnesium, and more inert than either aluminum or magnesium. Both scientific and practical uses of beryllium have recently attracted attention. Scientists have used the metal to study atomic structure, as when Chadwick discovered the neutron in 1932 with the aid of a disk of beryllium. Although discovered by Vauquelin in 1798, and prepared in impure metallic form by Woehler in 1828, a year after his production of metallic aluminum, so difficult is its reduction that beryllium has remained a laboratory rather than a commercial metal until recently. Due mainly to the efforts of the Beryllium Corporation in this country and of Siemens & Halske in Germany, methods of manufacture have been improved and prices reduced, with the result that a copper-beryllium alloy is now available for engineering use, and alloys of beryllium with iron, with aluminum, and with nickel may soon find their way into the market. Beryllium copper containing 2¼ per cent Be is sold in the form of sheets, strips, rods, wire, and tubes by the American Brass Company, of Waterbury, Conn., and the Riverside Metal Company, of Riverside, N. J. This alloy has high tensile strength, high fatigue limit, resists corrosion, is a good electrical conductor, is non-sparking, and may be heat-treated. These qualities open for it a wide field of possible use.

Fig. 1—A typical, abandoned mine shaft

Fig. 2—Completed bulkhead of reinforced concrete

Bulkheading Abandoned Shafts

A Public Works Project in the Tri-State District

Charles F. Williams

Mining Supervisor, Conservation Branch, United States Geological Survey, Miami, Okla.

THE United States Geological Survey has been bulkheading 50 mine shafts on restricted Indian allotments in the Quapaw Reservation, in northeastern Oklahoma. These shafts are in the vicinity of the towns of Lincolnville and Quapaw, where the lead and zinc mines can generally be classed as marginal producers and where mining operations have been practically abandoned for several years. The landowners are wards of the government, and their lands are restricted and leased and mined under the supervision of the mining division of the Survey's conservation branch.

Funds were allocated by the Public Works Administration for conservation work in eastern Oklahoma. The money is now being spent to preserve mine shafts, safeguard the openings (see Fig. 1), and prevent surface flood waters from entering the mines. Expenditures for safeguarding and preservation are confined to the restricted tracts where the mining leases have expired or have been surrendered.

The bulkheading jobs may be divided into three classes for better description. One class applies to the shallow shafts, averaging about 100 ft. in depth, in the Lincolnville area, where the Mayes (Mississippian) limestone bedrock is exposed at the surface and the shafts are sunk without cribbing; the only timbers used are placed at the shaft collar. To bulkhead these shafts, a 10x12-ft. or 11x11-ft. reinforced-concrete slab (see Fig. 2) is constructed on the shaft collar, extending about 2 ft. beyond the usual 6x8-ft. or 7x7-ft. shaft opening.

Another applies to those shafts in the Lincolnville area that have been sunk through loose boulders and soil and are cribbed to a depth of 10 or 15 ft. This cribbing (2x4 in. or 2x6 in.) has an average life of about five years if the shaft is not sealed. In many of these shafts the cribbing has given away, with the result that the collar has fun-

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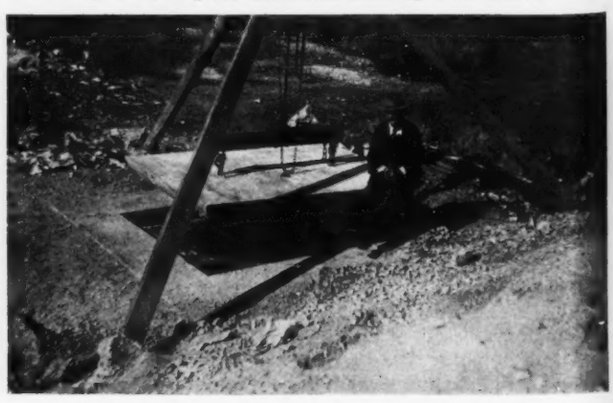
Fig. 3—Shaft re-cribbed before bulkheading

Fig. 4—Two-piece bulkhead showing slab raised



neled out, creating a cone-shaped opening as much as 30 ft. in diameter. When this condition is met, the sides of the cone are squared up and cut down to bedrock, upon which the bulkhead is constructed. (See Fig. 5.) The opening above the bulkhead is then filled to the surface, and a standard U.S.G.S. bench mark, set in a concrete block and stamped with the shaft number, is placed to indicate the position of the shaft.

The third class applies to the deeper shafts, averaging about 175 ft. in depth, in the Quapaw area, where the bedrock is correspondingly deeper. Owing to the failure of cribbing, caving has often extended from the collar to a depth of 40 or 50 ft. In many shafts a lens of Cherokee (Pennsylvanian) shale as much as several feet in thickness is exposed between the subsoil and the limestone. The shale slacks, and is therefore not a suitable formation to sustain a permanent bulkhead. When these conditions are encountered, the shaft is recribbed up from solid bedrock, and the bulkhead is placed at or near the surface. (See Fig. 3.)

In bulkheading shafts, consideration is given to their possible future use for mining. If from available records of prospect drilling, past production, or an inspection of ore in the dump, it appears that the shaft, in addition to being safeguarded, should also be made available for possible future development, a bulkhead with a removable slab, of shaft dimensions, is constructed at the collar. The frame that receives the slab is formed with 45-deg. inner sides, designed to keep the slab in position. This slab is therefore not dependent upon timbers for its support. (See Figs. 4 and 6.) Eyebolts of 1-in. steel are set in both types of slabs to facilitate removal should this be necessary at any future time.

The slabs average about 8 in. in thickness and contain about 3½ cu.yd. of concrete. Discarded 12-lb. mine rails crossed on 18-in. centers are used for reinforcing. (See Fig. 7.) Forms are constructed of 1-in. native oak lumber supported by 4x6-in. oak sills set in rock hitches on 24-in. centers. The

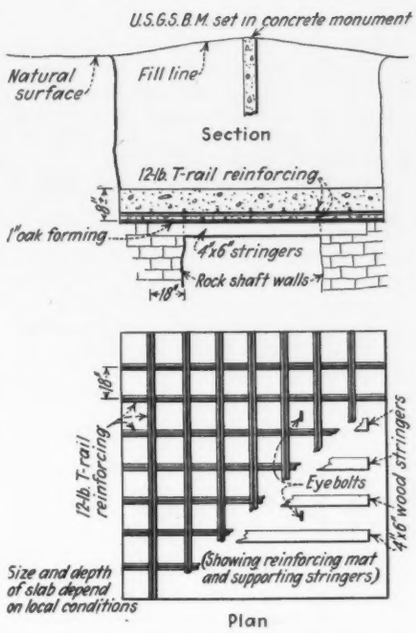


Fig. 5—Sketch showing plan and section of one-piece bulkhead on bedrock

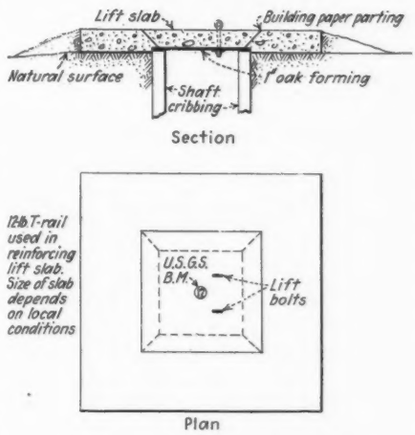


Fig. 6—Sketch showing plan and section of two-piece bulkhead at surface

▼

form is covered with building paper before the mat is laid and wired. In constructing the two-part bulkhead, the outer frame is poured first; when it has set, the inner form is removed and replaced by a building-paper parting. The inner slab is then poured, the paper parting being left in place.

The average cost of the bulkheads so far constructed will not exceed $75. It appears probable that the government policy of sealing unused mine shafts to preserve timbering, prevent caving, eliminate the hazard of unprotected openings, and protect the mines from flooding by surface waters will be adopted by mine operators on leased Indian lands. Departmental lessees are required to keep all shafts in good condition during the life of the lease, and bulkheading will eliminate maintenance expense after shafts are no longer needed for mining operations.

Forty men are employed on the project, which was one of the first to be started under the Public Works Administration. The men work on shaft jobs in groups of five. Until the form is completed, men working in the shaft are roped to steel pins. (See Fig. 8.) One man remains on top to handle the ropes, equipment, and materials. The safety rope, at first placed about the waists of the men, has since been replaced by the Mine Safety Appliances Company's safety belt.

In addition to the bulkheading work, three other jobs are included in the project. Sixty shallow shafts on unleased Indian lands are being filled as a safety measure and a means of controling mine floods. A number of sink holes in or near drainage channels are being cemented and plugged or diked, and several abandoned deep wells will be plugged and cemented. The natural sink holes referred to frequently take the entire run-off from areas of 1,000 acres or more, and this water must eventually find its way to the mine pumps. The measures being taken to keep this water out of the mines are expected to effect a substantial saving in pumping costs. This will be of public benefit by decreasing the burden of pumping to keep the mine levels open.

Fig. 7—Pouring concrete. Two eyebolts in place

Fig. 8—Safety ropes and belt used in this work

Obviously, part of this benefit will accrue to the considerable area of restricted Indian mining lands.

The abandoned deep wells were drilled to supply water from the Rubidoux sandstone, which is cut at a depth of about 1,000 ft. Prior to about 1913 these wells furnished artesian flow, but as the use of this water was extended, the head gradually decreased, and the water now stands from 200 to 225 ft. below the surface. Over a considerable part of the mining district the mine workings are below this level. These wells were drilled through more or less open and fractured formations and usually close to mine workings. When the casing rusts out, the artesian flow will find its way to the mines. This will not only increase the burden on the pumps but will also result in a further reduction in the water resources of the Tri-State district.

The project is under the general supervision of H. I. Smith, chief of the mining division of the Geological Survey. A. C. Spencer, of the geologic branch, made the mine-water survey to determine the economic value of the flood-control measures recommended. A. J. Kyte and E. W. McCuskey are employed as foremen.

Styles in Salting

Instances of Ingenuity Misapplied

Marc Pawl

WITH the new knowledge of metallurgy available and the great interest being shown in mining, especially in that of gold, one would expect that some new wrinkles might be developed in the ancient and dishonorable game of salting for suckers. Gold is so well known and gold brick artists have operated so long that it is difficult to originate entirely new tricks, but as long as "a sucker is born every minute" the same old games can be played on the later arrivals, and gold is not the only bait.

Some time ago I received a small specimen of crushed carnotite from an area in another country that is wholly unknown as a producer of strange and unusual minerals. The known geology was unpromising. The crushed mineral, which had evidently been fairly hard for carnotite, was not accompanied by country rock, and I could get no details of occurrence. As it was evidently being used to obtain at least a grubstake, I was naturally more or less suspicious.

Later a friend sent me from the same place a much larger specimen with larger pieces of carnotite and "country rock" mixed through the sample. The carnotite carried its own home address in the peculiar vegetal fossils of the Colorado-Utah carnotite field, and the country rock was diabase which "came clean" on washing in water and did not carry a trace of uranium mineral. And, believe it or not, an official report states that a small deposit of carnotite has been found at this particular locality!

Also from an adjoining country recently came a tiny sample of a metallic substance in minute angular grains, said to be from a placer. Heating changed the metal to a yellow pulverulent material soluble in ammonia. Evidently a tungsten filament from an incandescent lamp or possibly some other form of the metal had been carefully crushed or filed to make the fragments. This reminds one of the German mineral dealer who a few years since sold to a number of museums and collectors specimens weighing less than a gram each of "metallic tantalum" in gray metallic octahedrons with a slight iridescent tarnish, from some river in Siberia. The remarkable discovery was noted in scientific papers of several countries, but the available specimens were very small and expensive. Finally one mineralogist did the unexpected, sacrificed part of his little specimen on the altar of knowledge, and found not a trace of tantalum!

A gentleman came to the office with samples that had been sent to him by his "agent in the South" (who, however, seems to be a resident of the "Magic City" on Manhattan) and which he assured me would surprise me. The samples resembled the coquina of Florida, but were unconsolidated. To find the gold the sample must be crushed to about 100 mesh. To my unbelieving surprise a considerable string of very fine particles of gold was left in the pan from a quarter of a pound of the sample. Under the lens the gold was of three distinct varieties—coppery yellow particles possibly 1/200 in. across, bright yellow particles of the same size, and tiny golden granular cylindrical pieces of similar thickness and possibly three to five times as long. The first two looked perfectly natural; the third looked "phoney." After further work I found two or three tiny shavings like those described, and then it all became clear. Considerable trouble had been taken in the salting. Fine gold from two different sources had been collected and added to the sample, then an amalgam of the fine shavings had been made and rolled down until it would simulate the natural particles in diameter, and the mercury was then driven off. A few shavings had either been spilled or were added with the idea that the sample would probably not be seen by anyone familiar with placer gold or who would examine it so carefully. The scheme almost succeeded, for it had passed several mining men without detection.

While on the subject of salting it may be worth while to relate a story of mental salting that I ran into in northern California more than 30 years ago. I happened to visit the cabin of a man acting as watchman at a tunnel said to be 900 ft. long near Pit River. He told me that a few years before a man had started a prospect tunnel there on a copper stain which did not develop into anything better. Some miles away was a rich thin stringer showing free gold. Armed with a few samples of the gold ore, this son of toil went to San Francisco and told some alert business men about the fine copper showings he had on Pit River, and to prove his story showed the samples of gold ore. He explained that he was too poor to have the ore assayed, but that if they cared to see how much copper it carried he would leave the samples. The gold returns were so large that the business men's cupidity rose as high as could be hoped. By adroit questioning they learned that the prospector was wholly unsuspecting about gold, but he insisted that he had an exceedingly fine copper prospect.

A man was sent back with him to sample the prospect, and he stayed with the simple prospector. In the presence of such guilelessness it did not seem necessary to protect his samples, and when he got back to San Francisco the assay returns were about as of the first sample. The gold results were not revealed to the prospector, but $20,000 was paid to him for his "copper property."

However, like some others, he was spoiled by success. He did so well with the copper mine that soon afterward he sold a gold mine on samples from the same little vein, and at the time of my visit was said to be in the penitentiary cogitating on the fickleness of fate.

PRODUCTION COSTS

Prorated on Basis of Metals Comprising Output

H. D. Keiser

Associate Editor

STATISTICS presented in the first article of this series, "Costs, Codes, and the Future," which appeared in the April issue, tended to show that an inseparable relation exists between the cost of producing the non-ferrous metals and the price that can be obtained for them. In each of the tables presented in that article, all revenues were credited to the production of the specific metal under consideration.

The accompanying tables show production costs prorated on the basis of the various metals comprising the output of the various companies listed, which include most of the domestic companies mining and smelting copper, lead, and zinc, as well as some of the larger foreign companies. Rhodesian copper mines have not been included, as they have been operated only a few years, and comparable analyses of their costs could not be made. In each instance where the necessary data were available, the period of 1922-1932 was used. Notations in the tables indicate those instances where a different period had to be employed. To keep this part of the study uniform with that which has already been presented, the prorated costs were calculated, first, on the basis of dividends, then on dividends plus bonded interest, and finally on net earnings. The tables show, for any one of the companies listed, the relative importance of each metal comprising the company's total metal output; also, they indicate the competitive advantage that one company may have over another.

This is the second article in a series devoted to a study of production costs, consisting largely of tables prepared by the Minerals Division of the U. S. Bureau of Foreign and Domestic Commerce.

Prorated Production Costs of Mining Companies

Prepared by the Minerals Division, U. S. Bureau of Foreign and Domestic Commerce
(Sources: Production data, American Bureau of Metal Statistics and U. S. Bureau of Mines; financial data, Moody's Investors Service and the Mines Handbook, by Rand and Sturgis)

	COPPER	LEAD	ZINC	SILVER	GOLD	TOTAL
ANACONDA COPPER (1) (YEARS, 1922 TO 1932 INCLUSIVE)						
Production (lb. and oz.)	2,186,072,000	191,241,352	2,000,862,000	101,009,737	354,000	
Sales receipts (estimate)	59.3%	2.7%	24.5%	12.0%	1.5%	$495,848,559
Based on Dividends:						
Prorated dividends ($)	56,469,971	2,571,145	23,330,764	11,427,313	1,428,414	95,227,607
Sales price per unit (c.)	13.448	7.104	6.072	58.871	$20.67183	.....
Dividends per unit (c.)	2.583	1.344	1.166	11.313	$4.03507	.....
Cost per unit (c.)	10.865	5.760	4.906	47.558	$16.63676	.....
Based on Dividends Plus Bond Interest:						
Prorated dividends plus bond interest ($)	94,267,121	4,292,095	38,946,787	19,075,977	2,384,497	158,966,477
Sales price per unit (c.)	13.448	7.104	6.072	58.871	$20.67183	.....
Dividends plus bond interest per unit (c.)	4.312	2.244	1.947	18.885	$6.73587	.....
Cost per unit (c.)	9.136	4.860	4.125	39.986	$13.93596	.....
Based on Earnings:						
Prorated earnings ($)	62,380,940	2,840,279	25,772,901	12,623,462	1,577,933	105,195,515
Sales price per unit (c.)	13.448	7.104	6.072	58.871	$20.67183	.....
Net earnings per unit (c.)	2.854	1.485	1.288	12.497	$4.45743	.....
Cost per unit (c.)	10.594	5.619	4.784	46.374	$16.22440	.....
CALUMET & ARIZONA (YEARS 1922-1930 INCLUSIVE; 1931 CONSOLIDATED WITH PHELPS DODGE)						
Production (lb. and oz.)	524,913,120	.....	.....	9,829,015	356,668	
Sales receipts (estimate)	85.6%	.....	.....	6.2%	8.2%	90,209,271
Based on Dividends:						
Prorated dividends ($)	25,229,441	.....	.....	1,827,366	2,416,839	29,473,646
Sales price per unit (c.)	14.711	.....	.....	57.123	$20.67183	.....
Dividends per unit (c.)	4.806	.....	.....	18.592	$6.77616	.....
Cost per unit (c.)	9.905	.....	.....	38.531	$13.89567	.....
Based on Dividends and Bond Interest:						
No bonded debt						
Based on Earnings:						
Prorated earnings ($)	21,263,717	.....	.....	1,540,129	2,036,945	24,840,791
Sales price per unit (c.)	14.711	.....	.....	57.123	$20.67183	.....
Net earnings per unit (c.)	4.051	.....	.....	15.669	$5.71104	.....
Cost per unit (c.)	10.660	.....	.....	41.454	$14.96079	.....
KENNECOTT (UTAH, BRADEN AND ALASKA; YEARS 1922-1932 INCLUSIVE)						
Production (lb. and oz.)	4,250,740,227	.....	.....	10,192,158	795,371	
Sales receipts (estimate)	96.2%	.....	.....	1.0%	2.8%	592,442,283
Based on Dividends:						
Prorated dividends ($)	193,957,135	.....	.....	2,016,186	5,645,322	201,618,643
Sales price per unit (c.)	13.414	.....	.....	56.920	$20.67183	.....
Dividends per unit (c.)	4.563	.....	.....	19.782	$7.09772	.....
Cost per unit (c.)	8.851	.....	.....	37.138	$13.57411	.....
Based on Dividends and Bond Interest:						
Prorated dividends and bond interest ($)	198,084,962	.....	.....	2,059,095	5,765,467	205,909,524
Sales price per unit (c.)	13.414	.....	.....	56.920	$20.67183	.....
Dividends and bond interest per unit (c.)	4.660	.....	.....	20.203	$7.24878	.....
Cost per unit (c.)	8.754	.....	.....	36.717	$13.42305	.....
Based on Earnings:						
Prorated earnings ($)	211,083,653	.....	.....	2,194,217	6,143,807	.....
Sales price per unit (c.)	13.414	.....	.....	56.920	$20.67183	.....
Net earnings per unit (c.)	4.966	.....	.....	21.528	$7.72445	.....
Cost per unit (c.)	8.448	.....	.....	35.392	$12.94738	.....
MOTHER LODE COALITION MINES (YEARS 1922-1932 INCLUSIVE)						
Production (lb. and oz.)	215,016,860	.....	.....	1,683,678	.....	
Sales receipts (estimate)	96.6%	.....	.....	3.4%	.....	30,199,776
Based on Dividends:						
Prorated dividends ($)	13,524,000	.....	.....	476,000	.....	14,000,000
Sales price per unit (c.)	13.567	.....	.....	61.062	.....	.....
Dividend per unit (c.)	6.290	.....	.....	28.271	.....	.....
Cost per unit (c.)	7.277	.....	.....	32.791	.....	.....
Based on Dividends and Bond Interest:						
No bonded debt						
Based on Earnings:						
Prorated earnings ($)	4,159,139	.....	.....	146,388	.....	4,305,527
Sales price per unit (c.)	13.567	.....	.....	61.062	.....	.....
Earnings per unit (c.)	1.934	.....	.....	8.695	.....	.....
Cost per unit (c.)	11.633	.....	.....	52.367	.....	.....

Prorated Production Costs of Mining Companies—*Continued*

	COPPER	LEAD	ZINC	SILVER	GOLD	TOTAL
MAGMA COPPER (YEARS 1922-1932 INCLUSIVE)						
Production (lb. and oz.)	274,061,188	.....	.....	7,931,704	90,395	
Sales receipts (estimate)	86.3%	.....	.....	9.4%	4.3%	$43,388,176
Based on Dividends:						
Prorated dividends ($)	7,705,134	.....	.....	839,262	383,917	8,928,313
Sales price per unit (c.)	13.650	.....	.....	51.809	$20.67183	.....
Dividends per unit (c.)	2.811	.....	.....	10.581	$4.24710	.....
Costs per unit (c.)	10.839	.....	.....	41.308	$16.42473	.....
Based on Dividends and Bond Interest:						
Prorated dividend and bond interest ($)	8,348,533	.....	.....	909,342	415,976	9,673,851
Sales price per unit (c.)	13.650	.....	.....	51.809	$20.67183	.....
Dividend plus bond interest per unit (c.)	3.046	.....	.....	11.465	$4.60175	.....
Cost per unit (c.)	10.604	.....	.....	40.344	$16.07008	.....
Based on Earnings:						
Prorated earnings ($)	6,858,362	.....	.....	747,029	341,726	7,947,117
Sales price per unit (c.)	13.650	.....	.....	51.809	$20.67183	.....
Net earnings per unit (c.)	2.502	.....	.....	9.418	$3.78036	.....
Cost per unit (c.)	11.148	.....	.....	42.391	$16.89147	.....
NEVADA CONSOLIDATED (2) (YEARS 1922-1932 INCLUSIVE)						
Production (lb. and oz.)	1,994,264,157	.....	.....	1,308,404	335,203	
Sales receipts (estimate)	97.3%	.....	.....	0.2%	2.5%	280,596,451
Based on Dividends:						
Prorated dividends ($)	45,765,800	.....	.....	94,072	1,175,894	47,035,766
Sales price per unit (c.)	13.687	.....	.....	53.759	$20.67183	.....
Dividends per unit (c.)	2.295	.....	.....	7.190	$3.50801	.....
Costs per unit (c.)	11.392	.....	.....	47.569	$17.16382	.....
Based on Dividends and Bond Interest:						
Prorated dividends and bond interest ($)	47,058,218	.....	.....	96,728	1,209,101	48,364,047
Sales price per unit (c.)	13.687	.....	.....	53.759	$20.67183	.....
Dividend plus bond interest per unit (c.)	2.359	.....	.....	7.393	$3.60707	.....
Cost per unit (c.)	11.328	.....	.....	47.366	$17.06476	.....
Based on Earnings:						
Prorated earnings ($)	54,730,323	.....	.....	112,498	1,406,226	56,249,047
Sales price (c.)	13.687	.....	.....	53.759	$20.67183	.....
Earnings per unit (c.)	2.744	.....	.....	8.598	$4.19515	.....
Cost per unit (c.)	10.943	.....	.....	45.161	$16.47668	.....
NEW CORNELIA (YEARS 1922-1928 INCLUSIVE) (CONSOLIDATED WITH CALUMET & ARIZONA IN 1929)						
Production (lb. and oz.)	431,367,514	.....	.....	978,934	77,726	
Sales receipts (estimate)	96.4%	.....	.....	1.0%	2.6%	61,501,868
Based on Dividends:						
Prorated dividends ($)	15,790,320	.....	.....	163,800	425,880	16,380,000
Sales price per unit (c.)	13.743	.....	.....	62.505	$20.67183	.....
Dividends per unit (c.)	3.661	.....	.....	16.732	$5.47925	.....
Costs per unit (c.)	10.082	.....	.....	45.773	$15.19258	.....
Based on Dividends and Bond Interest:						
No bonded debt						
Based on Earnings:						
Prorated earnings ($)	13,091,429	.....	.....	135,803	353,088	13,580,320
Sales price per unit (c.)	13.743	.....	.....	62.505	$20.67183	.....
Earnings per unit (c.)	3.035	.....	.....	13.873	$4.54273	.....
Cost per unit (c.)	10.708	.....	.....	48.632	$16.12910	.....
OLD DOMINION (YEARS 1922-1931 INCLUSIVE; CLOSED DOWN IN 1932)						
Production (lb. and oz.)	210,685,031	.....	.....	1,160,025	43,553	
Sales receipts (estimate)	94.7%	.....	.....	2.3%	3.0%	30,353,492
Based on Dividends or Deficit:						
Prorated deficit ($)	3,318,997	.....	.....	80,609	105,143	3,504,749
Sales price per unit (c.)	13.644	.....	.....	61.006	$20.67183	.....
Deficit per unit (c.)	1.575	.....	.....	6.949	$2.36822	.....
Cost per unit (c.)	15.229	.....	.....	67.955	$23.04005	.....
Based on Dividends and Interest on Bonded Indebtedness:						
No bonded debt						
Based on earnings:						
No earnings						
UTAH COPPER (YEARS 1922-1932 INCLUSIVE)						
Production (lb. and oz.)	2,110,147,163	.....	.....	7,024,101	795,371	
Sales receipts (estimate)	93.4%	.....	.....	1.3%	5.3%	309,720,920
Based on Dividends:						
Prorated dividends ($)	105,450,145	.....	.....	1,467,921	5,983,788	112,901,654
Sales price per unit (c.)	13.713	.....	.....	55.855	$20.67183	.....
Dividend per unit (c.)	4.997	.....	.....	20.895	$7.52327	.....
Cost per unit (c.)	8.716	.....	.....	34.960	$13.14856	.....
Based on Dividends and Bonded Indebtedness:						
No bonded debt						
Based on Earnings:						
Prorated earnings ($)	113,609,250	.....	.....	1,581,285	6,446,778	121,637,313
Sales price per unit (c.)	13.713	.....	.....	55.855	$20.67183	.....
Earnings per unit (c.)	5.384	.....	.....	22.512	$8.10537	.....
Cost per unit (c.)	8.329	.....	.....	33.343	$12.56646	.....
UNITED VERDE (YEARS 1922-1931 INCLUSIVE; CLOSED DOWN IN 1932)						
Production (lb. and oz.)	903,552,152	.....	.....	16,909,059	461,621	
Sales receipts (estimate)	86.9%	.....	.....	6.7%	6.4%	148,600,750
Based on Dividends:						
Prorated dividends ($)	33,369,600	.....	.....	2,572,800	2,457,600	38,400,000
Sales price per unit (c.)	14.285	.....	.....	59.067	$20.67183	.....
Dividend per unit (c.)	3.693	.....	.....	15.216	$5.32383	.....
Cost per unit (c.)	10.572	.....	.....	43.851	$15.34800	.....
Based on Dividends and Bonded Indebtedness:						
No bonded debt						
Based on Earnings:						
No data available						
UNITED VERDE EXTENSION (YEARS 1922-1932 INCLUSIVE)						
Production (lb. and oz.)	460,696,000	.....	.....	3,854,685	102,908	
Sales receipts (estimate)	93.6%	.....	.....	3.2%	3.2%	65,710,484
Based on Dividends:						
Prorated dividends ($)	23,228,300	.....	.....	794,130	794,130	24,816,560
Sales price per unit (c.)	13.347	.....	.....	54.287	$20.67183	.....
Dividend per unit (c.)	5.042	.....	.....	20.602	$7.71689	.....
Cost per unit (c.)	8.305	.....	.....	33.685	$12.95494	.....
Based on Dividends and Bonded Indebtedness:						
No bonded debt						
Based on Deficit:						
Prorated deficit ($)	39,114	.....	.....	1,337	1,337	41,788
Sales price per unit (c.)	13.347	.....	.....	54.287	$20.67183	.....
Deficit per unit (c.)	0.008	.....	.....	0.035	$0.01299	.....
Cost per unit (c.)	13.355	.....	.....	54.252	$20.65884	.....

(1) Exclusive of Andes Copper Company, Chile Copper Corporation, and Greene Cananea Copper Company; but does include International Smelting Company and all other subsidiaries.

(2) Ray and Chino mines included in figures prior to 1926; after that year consolidated with Nevada Consolidated.

Prorated Production Costs of Mining and Smelting Companies

Prepared by the Minerals Division, U. S. Bureau of Foreign and Domestic Commerce.
(Sources: Production data, American Bureau of Metal Statistics; financial data, Moody's Investors Service and the Mines Handbook, by Rand and Stu ia)

	COPPER	LEAD	ZINC	SILVER	GOLD	TOTAL
AMERICAN METAL (YEARS 1922-1932 INCLUSIVE)						
Production (lb. and oz.)	3,921,094,000	2,410,212,000	1,065,096,000	402,772,451	4,177,405	
Sales receipts (estimate)	49.4%	15.3%	6.3%	20.8%	8.2%	$1,055,018,989
Based on Dividends:						
Prorated dividends ($)	10,108,602	3,130,802	1,289,154	4,256,254	1,677,946	20,460,758
Sales price per unit (c.)	13.283	6.697	6.243	54.603	$20.67183	.....
Dividends per unit (c.)	0.258	0.130	0.121	1.057	$0.40167	.....
Cost per unit (c.)	13.025	6.567	6.122	53.546	$20.27016	.....
Based on Dividends Plus Bond Interest:						
Prorated dividends plus bond interest ($)	11,631,769	3,602,552	1,483,404	4,897,587	1,930,780	23,546,092
Sales price per unit (c.)	13.283	6.697	6.243	54.603	$20.67183	.....
Dividends plus bond interest per unit (c.)	0.297	0.149	0.139	1.216	$0.46219	.....
Cost per unit (c.)	12.986	6.548	6.104	53.387	$20.20964	.....
Based on Earnings:						
Prorated earnings ($)	11,553,134	3,578,197	1,473,375	4,864,477	1,917,727	23,386,910
Sales price per unit (c.)	13.283	6.697	6.243	54.603	$20.67183	.....
Net earnings per unit (c.)	0.295	0.149	0.138	1.208	$0.45907	.....
Cost per unit (c.)	12.988	6.548	6.105	53.395	$20.21276	.....
AMERICAN SMELTING & REFINING (YEARS 1922 TO 1932 INCLUSIVE)						
Production (lb. and oz.)	9,514,684,000	9,048,398,000	995,928,000	884,585,471	17,696,590	
Sales receipts (estimate)	46%	21.5%	2%	17.5%	13%	2,823,255,169
Based on Dividends:						
Prorated dividends ($)	37,466,170	17,511,362	1,628,964	14,253,434	10,588,265	81,448,195
Sales price per unit (c.)	13.684	6.693	5.700	55.734	$20.67183	.....
Dividends per unit (c.)	0.394	0.194	0.164	1.611	$0.59832	.....
Cost per unit (c.)	13.290	6.499	5.536	54.123	$20.08351	.....
Based on Dividends Plus Bond Interest:						
Prorated dividends plus bond interest ($)	48,450,489	22,645,338	2,106,544	18,432,252	13,692,529	105,327,152
Sales price per unit (c.)	13.684	6.693	5.700	55.734	$20.67183	.....
Dividends plus bond interest per unit (c.)	0.509	0.250	0.212	2.084	$0.77374	.....
Cost per unit (c.)	13.175	6.443	5.488	53.650	$19.89809	.....
Based on Earnings:						
Prorated earnings ($)	56,278,380	26,304,025	2,446,886	21,410,253	15,904,760	122,344,304
Sales price per unit (c.)	13.684	6.693	5.700	55.734	$20.67183	.....
Net earnings per unit (c.)	0.591	0.291	0.246	2.420	$0.89875	.....
Cost per unit (c.)	13.093	6.402	5.454	53.314	$19.77308	.....
BINGHAM MINES (YEARS 1922 TO 1928 INCLUSIVE)						
Production (lb. and oz.)	5,499,000	93,040,000	4,454,000	7,853,601	31,632	
Sales receipts (estimate)	5.6%	50.6%	2.3%	36.7%	4.8%	13,559,955
Based on Dividends:						
Prorated dividends ($)	40,173	362,992	16,500	263,276	34,434	.....
Sales price per unit (c.)	13.817	7.363	7.020	63.449	$20.67183	.....
Dividends per unit (c.)	0.731	0.390	0.370	3.352	$1.08858	.....
Cost per unit (c.)	13.086	6.973	6.650	60.097	$19.58325	.....
No bonded debt						
Based on Earnings:						
Prorated earnings ($)	62,501	564,745	25,670	409,607	53,573	.....
Sales price per unit (c.)	13.817	7.363	7.020	63.449	$20.67183	.....
Net earnings per unit (c.)	1.137	0.607	0.576	5.216	$1.69363	.....
Cost per unit (c.)	12.680	6.756	6.444	58.233	$18.97820	.....
BUNKER HILL & SULLIVAN (YEARS 1922 TO 1932 INCLUSIVE)						
Production (lb. and oz.)	.....	908,220,000	45,740,000	17,094,223	.....	
Sales receipts (estimate)	.....	84.2%	2.9%	12.9%	.....	69,465,623
Based on Dividends:						
Prorated dividends ($)	.....	18,802,439	647,624	2,880,812	.....	22,331,875
Sales price per unit (c.)	.....	6.439	4.450	52.343	.....	.....
Dividends per unit (c.)	.....	2.070	1.416	16.852	.....	.....
Cost per unit (c.)	.....	4.369	3.034	35.491	.....	.....
No bonded debt						
Based on Earnings:						
Prorated earnings ($)	.....	21,573,574	743,033	3,305,215	.....	25,621,822
Sales price per unit (c.)	.....	6.439	4.450	52.343	.....	.....
Net earnings per unit (c.)	.....	2.375	1.147	19.335	.....	.....
Cost per unit (c.)	.....	4.064	3.303	33.008	.....	.....
BUTTE & SUPERIOR (YEARS 1922 TO 1930 INCLUSIVE)						
Production (lb. and oz.)	47,140,000	65,866,000	567,336,000	15,229,504	13,932	
Sales receipts (estimate)	11.3%	8.4%	63.5%	16.3%	0.5%	57,501,738
Based on Dividends:						
Prorated dividends ($)	377,112	280,331	2,119,167	543,975	16,686	3,337,271
Sales price per unit (c.)	13.769	7.370	6.430	61.640	$20.67183	.....
Dividends per unit (c.)	0.800	0.426	0.374	3.572	$1.19767	.....
Cost per unit (c.)	12.969	6.944	6.056	58.068	$19.47416	.....
No bonded debt						
Based on Earnings:						
Prorated earnings ($)	111,029	82,535	623,926	160,157	4,913	982,560
Sales price per unit (c.)	13.769	7.370	6.430	61.640	$20.67183	.....
Net earnings per unit (c.)	0.236	0.125	0.110	1.052	$0.35264	.....
Cost per unit (c.)	13.533	7.245	6.320	60.588	$20.31919	.....
CALLAHAN ZINC-LEAD (YEARS 1922 TO 1932 INCLUSIVE)						
Production (lb. and oz.)	.....	23,040,000	25,992,004	773,041	.....	
Sales receipts (estimate)	.....	42.4%	45.7%	11.9%	.....	3,706,297
Based on Dividends:						
Prorated dividends ($)	.....	———	No Dividends Paid	———	———	———
Sales price per unit (c.)	.....	6.825	6.512	57.077	.....	.....
Dividends per unit (c.)	.....	.....	.....	.....	.....	.....
Cost per unit (c.)	.....	.....	.....	.....	.....	.....
No bonded debt						
Based on Earnings:						
Prorated earnings ($)	.....	D.—378,426	D.—407,879	D.—106,209	.....	D.—892,514
Sales price per unit (c.)	.....	6.825	6.512	57.077	.....	.....
Net earnings per unit (c.)	.....	D.— 1.642	D.— 1.569	D.— 13.739	.....	.....
Cost per unit (c.)	.....	8.467	8.181	70.816	.....	.....
DAYROCK MINING (YEARS 1923 TO 1930 INCLUSIVE)						
Production (lb. and oz.)	.....	25,404,000	.....	779,193	.....	
Sales receipts (estimate)	.....	79.7%	.....	20.3%	.....	2,077,352
Based on Dividends:						
Prorated dividends ($)	.....	202,410	.....	51,555	.....	253,965
Sales price per unit (c.)	.....	6.520	.....	54.034	.....	.....
Dividends per unit (c.)	.....	0.797	.....	6.616	.....	.....
Cost per unit (c.)	.....	5.723	.....	47.418	.....	.....
No bonded debt						
Based on Earnings:						
Prorated earnings ($)	.....	.....	.....	.....	.....	.....
Sales price per unit (c.)	.....	.....	.....	.....	.....	.....
Net earnings per unit (c.)	.....	——Not sufficient earnings data——			.....	.....
Cost per unit (c.)	.....	.....	.....	.....	.....	.....

Prorated Production Costs of Mining and Smelting Companies—*Continued*

	COPPER	LEAD	ZINC	SILVER	GOLD	TOTAL
CHIEF CONSOLIDATED (YEARS 1922 TO 1932 INCLUSIVE)						
Production (lb. and oz.)	8,508,000	178,218,000	21,918,000	22,425,312	111,885	
Sales receipts (estimate)	3.7%	40.9%	4.8%	43.4%	7.2%	$31,957,656
Based on Dividends:						
Prorated dividends ($)	68,523	757,465	88,896	803,765	133,343	1,851,992
Sales price per unit (c.)	13.728	7.339	6.972	61.845	$20.67183	.....
Dividends per unit (c.)	0.805	0.425	0.406	3.584	$1.19179	.....
Cost per unit (c.)	12.923	6.914	5.566	58.261	$19.48004	.....
Based on Dividends Plus Bond Interest:						
Prorated dividends plus bond interest ($)	79,047	873,792	102,548	927,202	153,821	2,136,410
Sales price per unit (c.)	13.728	7.339	6.972	61.845	$20.67183	.....
Dividends plus bond interest per unit (c.)	0.929	0.490	0.468	4.135	$1.37481	.....
Cost per unit (c.)	12.799	6.849	6.504	57.710	$19.29702	.....
Based on Earnings:						
Prorated earnings ($)	106,873	1,181,375	138,645	1,253,586	207,968	2,888,447
Sales price per unit (c.)	13.728	7.339	6.972	61.845	$20.67183	.....
Net earnings per unit (c.)	1.256	0.663	0.587	0.559	$1.85877	.....
Cost per unit (c.)	12.672	6.676	6.385	61.286	$18.81306	.....
FEDERAL MINING AND SMELTING (YEARS 1922 TO 1932 INCLUSIVE)						
Production (lb. and oz.)	.....	809,322,000	709,652,000	17,380,805	2,407	
Sales receipts (estimate)	.....	49.88%	41.22%	8.86%	0.04%	111,258,596
Based on Dividends:						
Prorated dividends ($)	.....	4,290,292	3,545,426	762,069	3,440	8,601,227
Sales price per unit (c.)	.....	6.856	6.463	56.695	$20.67183	.....
Dividends per unit (c.)	.....	0.530	0.500	4.385	$1.42916	.....
Cost per unit (c.)	.....	6.326	5.963	52.310	$19.24267	.....
No bonded debt						
Based on Earnings:						
Prorated earnings ($)	.....	6,302,209	5,208,040	1,119,438	5,054	12,634,741
Sales price per unit (c.)	.....	6.856	6.463	56.695	$20.67183	.....
Net earnings per unit (c.)	.....	0.779	0.734	6.441	$2.09971	.....
Cost per unit (c.)	.....	6.077	5.729	50.254	$18.57212	.....
HECLA MINING (YEARS 1922 TO 1932 INCLUSIVE)						
Production (lb. and oz.)	.....	542,578,000	4,118,201	15,215,012	.....	
Sales receipts (estimate)	.....	80.8%	0.5%	18.7%	.....	44,127,936
Based on Dividends:						
Prorated dividends ($)	.....	9,049,600	56,000	2,094,400	.....	11,200,000
Sales price per unit (c.)	.....	6.575	4.870	54.256	.....	.....
Dividends per unit (c.)	.....	1.668	1.360	13.765	.....	.....
Cost per unit (c.)	.....	4.907	3.510	40.491	.....	.....
No bonded debt						
Based on Earnings:						
Prorated earnings ($)	.....	12,296,843	76,094	2,845,928	.....	15,218,865
Sales price per unit (c.)	.....	6.575	4.870	54.256	.....	.....
Net earnings per unit (c.)	.....	2.266	1.848	18.705	.....	.....
Cost per unit (c.)	.....	4.309	3.022	35.551	.....	.....
NEW JERSEY ZINC (YEARS 1922 TO 1928 INCLUSIVE)						
Production (lb. and oz.)	.....	.....	1,197,420,000	.....	.....	
Sales receipts (estimate)	.....	.....	100%	.....	.....	.....
Based on Dividends:						
Prorated dividends ($)	.....	.....	38,116,714	.....	.....	38,116,714
Sales price per unit (c.)	.....	.....	6.555	.....	.....	.....
Dividends per unit (c.)	.....	.....	3.183	.....	.....	.....
Cost per unit (c.)	.....	.....	3.372	.....	.....	.....
Based on Dividends Plus Bond Interest:						
Prorated dividends plus bond interest ($)	.....	.....	38,876,714	.....	.....	38,876,714
Sales price per unit (c.)	.....	.....	6.455	.....	.....	.....
Dividends plus bond interest per unit (c.)	.....	.....	3.247	.....	.....	.....
Cost per unit (c.)	.....	.....	3.308	.....	.....	.....
Based on Earnings:						
Prorated earnings ($)	.....	.....	44,235,328	.....	.....	44,235,328
Sales price per unit (c.)	.....	.....	6.555	.....	.....	.....
Net earnings per unit (c.)	.....	.....	3.694	.....	.....	.....
Cost per unit (c.)	.....	.....	2.861	.....	.....	.....
NORTH LILY (YEARS 1928 TO 1932 INCLUSIVE)						
Production (lb. and oz.)	.....	77,050,000	870,960	2,108,663	49,653	.....
Sales receipts (estimate)	.....	69.4%	0.7%	15.2%	14.7%	6,950,856
Based on Dividends:						
Prorated dividends ($)	.....	745,350	7,518	163,247	157,877	1,073,992
Sales price per unit (c.)	.....	6.258	5.641	49.965	$20.67183	.....
Dividends per unit (c.)	.....	0.967	0.863	7.742	$3.17961	.....
Cost per unit (c.)	.....	5.291	4.778	42.223	$17.49222	.....
Based on Dividends Plus Bond Interest:						
No bonded debt						
Prorated dividends plus bond interest ($)	.....	.....	.....	.....	.....	.....
Sales price per unit (c.)	.....	6.258	5.641	49.965	$20.67183	.....
Dividends plus bond interest per unit (c.)	.....	.....	.....	.....	.....	.....
Cost per unit (c.)	.....	.....	.....	.....	.....	.....
Based on Earnings:						
Prorated earnings ($)	.....	1,274,749	12,858	279,195	270,011	1,836,812
Sales price per unit (c.)	.....	6.258	5.641	49.965	$20.67183	.....
Net earnings per unit (c.)	.....	1.654	1.476	13.240	$5.43796	.....
Cost per unit (c.)	.....	4.604	4.165	36.725	$15.23387	.....
PARK UTAH CONSOLIDATED (YEARS 1922 TO 1932 INCLUSIVE)						
Production (lb. and oz.)	13,347,366	310,934,000	269,589,000	31,098,406	173,418	
Sales receipts (estimate)	2.9%	34.0%	28.7%	28.9%	5.5%	64,949,179
Based on Dividends:						
Prorated dividends ($)	228,395	2,677,732	2,260,321	2,276,072	433,162	7,875,682
Sales price per unit (c.)	13.985	7.084	6.289	60.365	$20.67183	.....
Dividends per unit (c.)	1.711	0.861	0.838	7.319	$2.49779	.....
Cost per unit (c.)	12.274	6.223	5.451	52.946	$18.17404	.....
No bonded debt						
Based on Earnings:						
Prorated earnings ($)	202,758	2,377,164	2,006,606	2,020,589	384,542	6,991,659
Sales price per unit (c.)	13.985	7.084	6.289	60.365	$20.67183	.....
Net earnings per unit (c.)	1.519	0.764	0.744	6.497	$2.21743	.....
Cost per unit (c.)	12.466	6.320	5.545	53.868	$18.45440	.....
ST. JOSEPH LEAD (YEARS 1922 TO 1932 INCLUSIVE)						
Production (lb. and oz.)	.....	3,203,684,000	446,260,000	.....	.....	
Sales receipts (estimate)	.....	90%	10%	.....	.....	236,207,337
Based on Dividends:						
Prorated dividends ($)	.....	46,884,212	5,209,357	.....	.....	52,093,569
Sales price per unit (c.)	.....	6.637	5.287	.....	.....	.....
Dividends per unit (c.)	.....	1.463	1.167	.....	.....	.....
Cost per unit (c.)	.....	5.174	4.120	.....	.....	.....
Based on Dividends Plus Bond Interest:						
Prorated dividends plus bond interest ($)	.....	47,928,662	5,325,407	.....	.....	53,254,069
Sales price per unit (c.)	.....	6.637	5.287	.....	.....	.....
Dividends plus bond interest per unit (c.)	.....	1.496	1.193	.....	.....	.....
Cost per unit (c.)	.....	5.141	4.094	.....	.....	.....
Based on Earnings:						
Prorated earnings ($)	.....	42,613,181	4,734,798	.....	.....	47,347,979
Sales price per unit (c.)	.....	6.637	5.287	.....	.....	.....
Net earnings per unit (c.)	.....	1.330	1.061	.....	.....	.....
Cost per unit (c.)	.....	5.307	4.226	.....	.....	.....

Prorated Production Costs of Mining and Smelting Companies—*Continued*

	COPPER	LEAD	ZINC	SILVER	GOLD	TOTAL
PHELPS DODGE (YEARS 1922 TO 1932 INCLUSIVE)						
Production (lb. and oz.)	1,879,513,160	75,526,000	610,709	28,050,670	481,402	
Sales receipts (estimate) (1)	56.4%	1.2%	.....	3.3%	2.3%	$440,720,000
Based on Dividends:						
Prorated dividends ($)	17,753,592	377,736	.....	1,038,774	723,994	31,478,000
Sales price per unit (c.)	13.228	6.824	6.607	51.802	$20.67183	.....
Dividends per unit (c.)	0.945	0.500	.....	3.703	$1.50378	.....
Cost per unit (c.)	12.283	6.324	6.607	48.099	$19.16805	.....
No bonded debt						
Based on Earnings:						
Prorated earnings ($)	D.—13,845,603	D.—244,587	.....	D.—810,115	D.—564,626	D.—24,548,941
Sales price per unit (c.)	13.328	6.824	6.607	51.802	$20.67183	.....
Net earnings per unit (c.)	D.— 0.737	0.324	.....	2.888	$ 1.17288	.....
Cost per unit (c.)	14.065	7.148	6.607	54.690	$21.84471	.....
SILVER KING COALITION (YEARS 1922 TO 1932 INCLUSIVE)						
Production (lb. and oz.)	12,907,2	364,492,000	77,239,000	23,543,999	31,658	
Sales receipts (estimate)	3.9%	55.5%	9.9%	29.2%	1.5%	43,939,216
Based on Dividends:						
Prorate dividends ($)	380,004	5,407,746	964,624	2,845,156	146,156	9,743,686
Sales price per unit (c.)	13.307	6.696	5.462	54.512	$20.67183	.....
Dividends per unit (c.)	2.944	1.484	1.249	12.084	$ 4.61672	.....
Cost per unit (c.)	10.363	5.212	4.213	42.428	$16.05511	.....
No bonded debt						
Based on Earnings:						
Prorated earnings ($)	479,147	6,818,632	1,216,296	3,587,460	184,288	12,285,823
Sales price per unit (c.)	13.307	6.696	5.462	54.512	$20.67183	.....
Net earnings per unit (c.)	3.712	1.871	1.575	15.237	$ 5.82121	.....
Cost per unit (c.)	9.595	4.825	3.887	39.275	$14.85062	.....
TINTIC STANDARDS (YEARS 1922 TO 1932 INCLUSIVE)						
Production (lb. and oz.)	9,441,369	404,378,000	.....	33,449,244	185,094	
Sales receipts (estimate)	2.3%	53.9%	.....	36.4%	7.4%	52,114,950
Based on Dividends:						
Prorated dividends ($)	359,823	8,432,395	.....	5,694,605	1,157,695	15,644,518
Sales price per unit (c.)	12.953	6.942	.....	56.784	$20.67183	.....
Dividends per unit (c.)	3.811	2.085	.....	17.0.4	$ 6.25463	.....
Cost per unit (c.)	9.142	4.857	.....	39.750	$14.41720	.....
No bonded debt						
Based on earnings:						
Prorated earnings ($)	292,890	6,863,828	.....	4,635,313	942,344	12,734,375
Sales price per unit (c.)	12.953	6.942	.....	56.784	$20.67183	.....
Net earnings per unit (c.)	3.102	1.697	.....	13.858	$ 5.09116	.....
Cost per unit (c.)	9.851	5.245	....	42.926	$15.58067	.....
U. S. SMELTING, REFINING & MINING (YEARS 1922 TO 1932 INCLUSIVE)						
Production (lb. and oz.)	75,411,776	1,127,050,000	491,624,000	268,363,930	2,575,869	
Sales receipts (estimate)	3.3%	24.3%	9.1%	46.2%	17.1%	311,384,028
Based on Dividends:						
Prorated dividends ($)	912,429	6,718,795	2,516,092	12,774,004	4,728,041	27,649,361
Sales price per unit (c.)	13.641	6.715	5.789	53.550	$20.67183	.....
Dividends per unit (c.)	1.210	0.596	0.512	4.760	$ 1.83551	.....
Cost per unit (c.)	12.431	6.119	5.277	48.790	$18.83632	.....
Based on Dividends Plus Bond Interest:						
Prorated dividends plus bond interest ($)	1,062,726	7,825,529	2,930,548	14,878,165	5,506,853	32,203,821
Sales price per unit (c.)	13.641	6.715	5.789	53.550	$20.67183	.....
Dividends plus bond interest per unit (c.)	1.409	0.694	0.596	5.544	$ 2.13786	.....
Cost per unit (c.)	12.232	6.021	5.193	48.006	$18.53397	.....
Based on Earnings:						
Prorated Earnings ($)	1,266,487	9,325,952	3,492,435	17,730,823	6,562,707	38,378,404
Sales price per unit (c.)	13.641	6.715	5.789	53.550	$20.67183	.....
Net earnings per unit (c.)	1.679	0.827	0.710	6.607	$ 2.54776	.....
Cost per unit (c.)	11.962	5.888	5.079	46.943	$18.12407	.....
UTAH APEX (YEARS 1922 TO 1932 INCLUSIVE)						
Production (lb. and oz.)	35,498,000	232,780,000	98,126,000	4,652,335	51,164	
Sales receipts (estimate)	15.3%	52.9%	20.0%	8.5%	3.3%	32,385,739
Based on Dividends:						
Prorated dividends ($)	343,462	1,187,526	448,970	190,812	74,080	2,244,850
Sales price per unit (c.)	13.922	7.358	6.616	59.438	$20.67183	.....
Dividends per unit (c.)	0.968	0.510	0.458	4.101	$ 1.44789	.....
Cost per unit (c.)	12.950	6.848	6.158	55.337	$19.22394	.....
No bonded debt						
Based on Earnings:						
Prorated earnings ($)	201,462	696,558	263,349	111,923	43,452	1,316,744
Sales price per unit (c.)	13.922	7.358	6.616	59.438	$20.67183	.....
Net earnings per unit (c.)	0.568	0.299	0.268	2.406	$ 0.84927	.....
Cost per unit (c.)	13.454	7.059	6.348	57.032	$19.82256	.....

D—Deficit.

(1) Sales of other products totalled 36.8%.

Prorated Production Costs of Foreign Mining Companies

Prepared by the Minerals Division, U. S. Bureau of Foreign and Domestic Commerce.
(Sources: Production data, American Bureau of Metal Statistics; financial data, Moody's Investors Service, and the Mines Handbook, by Rand and Sturgis)

	COPPER	LEAD	ZINC	SILVER	GOLD	TOTAL
ANDES COPPER (1) (YEARS 1927-1932 INCLUSIVE)						
Production (lb. and oz.)	522,092,254	.....	.....	853,802	51,551	
Sales receipts (estimate)	98.0%	.....	.....	0.6%	1.4%	.....
Based on Dividends:						
Prorated dividends ($)	10,611,928	.....	.....	64,971	151,599	$10,828,498
Sales price per unit (c.)	14.139	.....	.....	49.643	$20.67183	.....
Dividends per unit (c.)	2.033	.....	.....	7.609	$2.94076	.....
Cost per unit (c.)	12.106	.....	.....	42.034	$17.73107	.....
Based on Dividends and Bond Interest:						
Prorated dividends and bond interest ($)	16,084,836	.....	.....	98,479	227,783	16,413,098
Sales price per unit (c.)	14.139	.....	.....	49.643	$20.67183	.....
Dividend and bond interest per unit (c.)	3.081	.....	.....	11.534	$4.45739	.....
Cost per unit (c.)	11.058	.....	.....	38.109	$16.21444	.....
Based on Earnings:						
Prorated earnings ($)	18,525,689	.....	.....	113,423	264,652	18,903,764
Sales price per unit (c.)	14.139	.....	.....	49.643	$20.67183	.....
Net earnings per unit (c.)	3.548	.....	.....	13.284	$5.13381	.....
Cost per unit (c.)	10.591	.....	.....	36.359	$15.53802	.....
CERRO DE PASCO (YEARS 1922-1932 INCLUSIVE)						
Production (lb. and oz.)	903,666,000	123,042,000(2)	85,510,000(2)	137,528,000	363,577	
Sales receipts (estimate)	54.5%	3.4%	2.3%	36.4%	3.4%	219,351,507
Based on Dividends:						
Prorated dividends ($)	23,224,794	1,448,886	980,129	15,511,606	1,448,886	42,614,301
Sales price per unit (c.)	13.240	6.039	5.877	57.148	$20.67183	.....
Dividends per unit (c.)	2.570	1.178	1.146	11.117	$3.98509	.....
Cost per unit (c.)	10.670	4.861	4.731	46.031	$16.68674	.....

Prorated Production Costs of Foreign Mining Companies—*Continued*

	COPPER	LEAD	ZINC	SILVER	GOLD	TOTAL
CERRO DE PASCO (YEARS 1922-1932 INCLUSIVE)						
Based on Dividends and Bond Interest:						
Prorated dividends and bond interest ($)	23,779,255	1,483,476	1,003,528	15,881,926	1,483,476	$43,631,661
Sales price per unit (c.)	13.240	6.039	5.877	57.148	$20.67183	.....
Dividend and bond interest per unit (c.)	2.631	1.206	1.173	11.383	$4.08025	.....
Cost per unit (c.)	10.609	4.833	4.704	45.765	$16.59158	.....
Based on Earnings:						
Prorated earnings ($)	11,331,363	706,911	478,204	7,568,103	706,910	20,791,491
Sales price per unit (c.)	13.240	6.039	5.877	57.148	$20.67183	.....
Earnings per unit (net) (c.)	1.254	0.575	0.559	5.424	$1.94432	.....
Cost per unit (c.)	11.986	5.464	5.318	51.724	$18.73751	.....
GRANBY CONSOLIDATED (YEARS 1922-1932 INCLUSIVE)						
Production (lb. and oz.)	490,416,158	.....	.....	4,391,093	90,795	
Sales receipts (estimate)	93.7%	.....	.....	3.5%	2.8%	68,789,933
Based on Dividends:						
Prorated dividends ($)	7,510,602	.....	.....	280,545	224,437	8,015,584
Sales price per unit (c.)	13.149	.....	.....	55.306	$20.67183	.....
Dividend per unit (c.)	1.531	.....	.....	6.389	$2.47191	.....
Cost per unit (c.)	11.618	.....	.....	48.917	$18.19992	.....
Based on Dividends and Bond Interest:						
Prorated dividends and bond interest ($)	8,926,542	.....	.....	333,436	266,748	9,526,726
Sales price per unit (c.)	13.149	.....	.....	55.306	$20.67183	.....
Dividends per unit (c.)	1.820	.....	.....	7.593	$2.27708	.....
Cost per unit (c.)	11.329	.....	.....	47.713	$18.39475	.....
Based on Deficit:						
Prorated deficit ($)	3,588,827	.....	.....	134,054	107,244	3,830,125
Sales price per unit (c.)	13.149	.....	.....	55.306	$20.67183	.....
Deficit per unit (c.)	0.732	.....	.....	3.053	$1.18117	.....
Cost per unit (c.)	13.881	.....	.....	58.359	$21.75300	.....
GREENE CANANEA (YEARS 1922-1932 INCLUSIVE)						
Production (lb. and oz.)	388,909,021	.....	.....	4,985,001	66,687	
Sales receipts (estimate)	92.3%	.....	.....	5.2%	2.5%	55,190,494
Based on Dividends:						
Prorated dividends ($)	6,576,375	.....	...	370,500	178,125	7,125,000
Sales price per unit (c.)	13.102	.....	.....	57.320	$20.67183	.....
Dividends per unit (c.)	1.691	.....	.....	7.432	$2.67106	.....
Cost per unit (c.)	11.411	.....	.....	49.888	$18.00077	.....
Based on Dividends and Bond Interest:						
No bonded debt						
Based on Earnings:						
Prorated earnings ($)	6,118,399	.....	.....	344,699	165,720	6,628,818
Sales price per unit (c.)	13.102	.....	.....	57.320	$20.67183	.....
Earnings per unit (c.)	1.573	.....	.....	6.917	$2.48504	.....
Cost per unit (c.)	11.529	.....	.....	50.403	$18.18679	....
HUDSON BAY (YEARS 1930-1932 INCLUSIVE; PRODUCTION BEGAN IN 1930)						
Production (lb. and oz.)	75,598,781	.....	80,698,199	1,636,111	155,565	
Sales receipts (estimate)	45.0%	.....	23.0%	4.0%	28.0%	11,503,508
Based on Dividends:						
No dividends paid						
Based on Bond Interest:						
Prorated bond interest ($)	304,299	.....	155,531	27,049	189,342	676,221
Sales price per unit (c.)	6.841	.....	3.289	28.239	$20.67183	.....
Bond interest per unit (c.)	0.403	.....	0.193	1.653	$1.21712	.....
Cost per unit (c.)	6.438	.....	3.096	26.586	$19.45471	.....
Based on Deficit:						
Prorated deficit ($)	269,053	.....	137,516	23,916	167,411	597,896
Sales price per unit (c.)	6.841	.....	3.289	28.239	$20.67183	.....
Deficit per unit (c.)	0.356	.....	0.170	1.462	$1.07615	.....
Cost per unit (c.)	7.197	.....	3.359	29.701	$21.74798	.....
KENNECOTT (BRADEN AND ALASKA; YEARS 1922-1932 INCLUSIVE)						
Production (lb. and oz.)	2,140,593,064	.....	.....	3,168,057	.....	
Sales recipts (estimate)	99.3%	.....	.....	0.7%	.....	282,721,363
Based on Dividends:						
Prorated dividends ($)	88,095,920	.....	.....	621,019	.....	88,716,989
Sales price per unit (c.)	13.119	.....	.....	58.960	.....	.....
Dividend per unit (c.)	4.115	.....	.....	19.602	.....	.....
Cost per unit (c.)	9.004	.....	.....	39.358	.....	.....
Based on Dividends and Bond Interest:						
Prorated dividends and bond interest ($)	92,356,815	.....	.....	651,055	.....	93,007,870
Sales price per unit (c.)	13.119	.....	.....	58.960	.....	.....
Dividend and bond interest per unit (c.)	4.314	.....	.....	20.551	.....	.....
Cost per unit (c.)	8.805	.....	.....	38.409	.....	.....
Based on Earnings:						
Prorated earnings ($)	97,099,873	.....	.....	684,491	.....	97,784,364
Sales price per unit (c.)	13.119	.....	.....	58.960	.....	.....
Earnings per unit (c.)	4.536	.....	.....	21.606	.....	.....
Cost per unit (c.)	8.683	.....	.....	37.354	.....	.....
NORANDA MINES, LTD. (YEARS 1928-1932 INCLUSIVE; PRODUCTION BEGAN IN 1928)						
Production (lb. and oz.)	285,669,328	.....	.....	2,204,597	790,838	
Sales receipts (estimate)	65.5%	.....	.....	1.6%	32.9%	49,619,487
Based on Dividends:						
Prorated dividends ($)	5,164,283	.....	.....	126,150	2,593,968	7,884,401
Sales price per unit (c.)	11.376	.....	.....	35.124	$20.67183	.....
Dividend per unit (c.)	1.808	.....	.....	5.722	$3.28002	.....
Cost per unit (c.)	9.568	.....	.....	29.402	$17.39181	.....
Based on Dividends and Bond Interest:						
Prorated dividends and bond interest ($)	5,313,295	.....	.....	129,791	2,668,815	8,111,901
Sales price per unit (c.)	11.376	.....	.....	35.124	$20.67183	.....
Dividend and bond interest per unit (c.)	1.860	.....	.....	5.887	$3.37467	.....
Cost per unit (c.)	9.516	.....	.....	29.237	$17.29716	.....
Based on Earnings:						
Prorated earnings ($)	10,129,178	.....	.....	247,430	5,087,787	15,464,395
Sales price per unit (c.)	11.376	.....	.....	35.124	$20.67183	.....
Earnings per unit (c.)	3.546	.....	.....	11.223	$6.43341	.....
Cost per unit (c.)	7.830	.....	.....	23.901	$14.23842	.....
INTERNATIONAL NICKEL AND MOND NICKEL, 1926-1929	**NICKEL**		**PLATINUM**			
Production (lb. and oz.)	252,298,294	360,278,000	92,135	1,036,175	21,635	
Sales receipts (estimate)	22.34%	72.60%	4.47%	0.33%	0.26%	73,696,121
Based on Dividends:						
Prorated dividends ($)	6,832,735	22,204,859	1,367,159	100,931	79,521	30,585,205
Selling price per unit (c.)	15.380	35.000	$84.30	56,053	$20.67183	.....
Dividends per unit (c.)	2.708	6.163	$14.84	9.741	$3.67557	.....
Cost per unit (c.)	12.672	28.837	$69.46	46.312	$16.99626	.....
Based on Dividends and Bond Interest:						
Prorated dividends and bond interest ($)	7,267,614	23,618,119	1,454,173	107,355	84,583	32,531,845
Selling price per unit (c.)	15.380	35.000	$84.30	56.053	$20.67183	.....
Dividends and bond interest per unit (c.)	2.881	6.556	$15.78	10.361	$3.90954	.....
Cost per unit (c.)	12.499	28.444	$68.52	45.692	$16.76229	.....
Based on Earnings:						
Prorated earnings ($)	11,791,989	38,321,326	2,359,454	174,188	137,239	52,784,196
Sales price per unit (c.)	15.380	35.000	$84.30	56.053	$20.67183	.....
Earnings per unit (c.)	4.674	10.637	$25.61	16.811	$6.34338	.....
Cost per unit (c.)	10.706	24.363	$58.69	39.242	$14.32845	.....

(1) 1927 first full year production. (2) Lead and zinc production began in 1926.

Collection in Flotation

A Study of the Fundamentals Involved

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FROTHING supplies us with a mass of bubbles floating on the pulp. If the frothing oil has no collecting properties, this floating froth will have a desirable mineral content which will be relatively little different from that of the original feed. However, if a collecting agent is added, and if this reagent is properly chosen, the froth will have a desirable mineral content which will be several times that of the original feed. Therefore, collection is that element of a flotation operation which comprises selective attachment of certain mineral particles to bubbles.

The conditions of attachment of a solid surface to an air bubble or oil globule are shown in Fig. 1, where

T_1 = interfacial tension between solid and air or solid and oil.

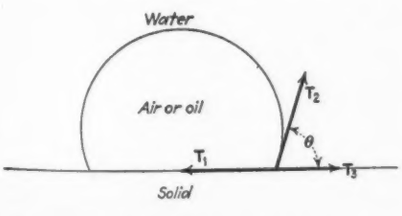
T_2 = interfacial tension between air and water or oil and water.

T_3 = interfacial tension between solid and water.

S = area of contact between air and solid or oil and solid.

Shepard[1] has shown that the classical expression $T_1 = T_3 + T_2 \cos \theta$ derived by Poincaré, Young, and others working on capillarity, also applies in the case of the attachment of an air bubble and a solid surface. He has also shown that the work required to pull a bubble from a mineral surface, which is really a measure of collectivity, is equal to $ST_2 (1 - \cos \theta)$. If we test particles in pure water, the quantity T_2, which may be measured directly with a surface-tension balance, remains constant throughout; while S reduces to unity when surfaces of unit area are compared. Therefore the work required to pull a bubble from a mineral surface becomes directly proportional to $(1 - \cos \theta)$. When the contact angle (θ) is 0 deg., then $1 - \cos \theta = 1 - \cos 0$ deg. $= 1 - 1 = 0$; or the collectivity is zero. Again, when the contact angle

Fig. 1—Conditions of attachment of a solid surface to air bubble or oil globule



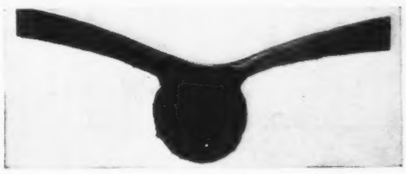


Fig. 2—A needle floating on water, photographed

(θ) is 180 deg. (the maximum possible), then $1 - \cos \theta = 1 - \cos 180$ deg. $= 1 - (-1) = 2$, or the maximum value which the quantity $(1 - \cos \theta)$ may have. This means, therefore, that when $\theta = 180$ deg., the collectivity is a maximum. Practically all the common collecting agents give contact angles between 45 deg. and 90 deg. In this range, the curve which shows the relation between θ and $(1 - \cos \theta)$ is substantially a straight line. Inasmuch as collectivity varies directly as the quantity $(1 - \cos \theta)$, we may say that, at least with common collecting agents, the collectivity varies directly as the contact angle.

Collecting Oils

The collecting oils come first chronologically and are practically no longer used. This class of reagents is marked by relative immiscibility in water.

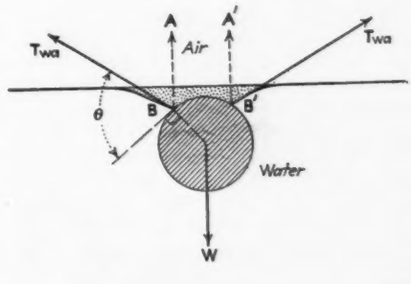
If a platinum needle is burned in a flame to red heat (all impurities on the surface are thus removed), cooled, and then carefully placed on a water-surface, it will sink. If, however, we oil this needle with Nujol (a mixture of paraffin oils) and then replace it on the water-surface, the needle will float.

Fig. 2 is a reproduction from a photograph of a needle floating on water and Fig. 3 is the force diagram showing the forces involved. In this diagram, the weight of the needle (W) minus the weight of the water displaced (the weight of the water displaced by the needle itself plus the weight of the volume of water represented in cross-section by the shaded area in Fig. 3) times the acceleration of gravity (to get the force in dynes) is equal to the upward components of the air-water surface tension (AB and $A'B'$, in dynes per centimeter) times one-half the length, in centimeters, of the needle-air-water contact line. In other words, the needle when oiled is kept from sinking due primarily to the surface tension of the water-air interface.

If a drop of water is placed on a clean surface of platinum, it will readily spread over it; if, however, it is placed on an oiled platinum surface, it will stand up on it as shown in Fig. 4. The contact angle (θ) will be similar to the contact angle (θ) of Fig. 3. In the case of clean platinum the contact angle (θ) is equal to zero; therefore, the upward components of the surface tension of the air-water interface are equal to zero, and the needle sinks. It seems, therefore, that a surface oiled with a paraffin hydrocarbon prevents water from spreading over it, and this is in accord with our every-day experience. Then, in order to attach a mineral particle to an air bubble, we must oil the surface of the particle. In the presence of water, oils show a preferential wetting of sulphide surfaces. This is brought out by the following interesting experiment:

If clean surfaces each of galena and calcite are placed on the bottom of a dish filled with water, and if drops of coal-tar creosote (a flotation oil somewhat heavier than water) are allowed to fall on the two surfaces, we find that oil flattens out on the galena surface, giving a contact angle which

Fig. 3—Force diagram showing forces involved when a needle floats on water



The second of a series of articles by Mr. del Giudice. An article dealing with frothing appeared in the April issue. Conditioning in flotation will be discussed next month.

[1] O. C. Shepard: "Bubble Attachment in Flotation." *Mining and Metallurgy*, Vol. 13, p. 282.

approaches 180 deg. (measured through the water), thereby showing its tendency to wet the sulphide surface. However, on the surface of calcite, the drop of oil retains an approximately spherical shape (contact angle equal to 0 deg.), thereby showing its reluctance to wet a calcite surface. (See Fig. 5.) In other words, the oil has a tendency to displace water at a sulphide surface, whereas no such tendency is manifested at a gangue surface.

The same conclusions may be reached by studying the behavior of captive air bubbles toward surfaces of sulphides and gangue minerals shaken in emulsions of oil in water. Thus we find that an air bubble will attach itself to the treated sulphide surface, but will not show any attachment to the treated gangue mineral surface. Again, if we test the behavior of air bubbles toward clean sulphide and clean gangue-mineral surfaces, no contact will be obtained.

If we apply the formula $T_1 = T_3 + T_2 \cos \theta$ to the problem, then, in the case

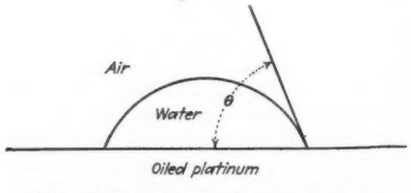
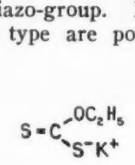


Fig. 4—Illustrating how a drop of water will stand up on an oiled platinum surface. See text

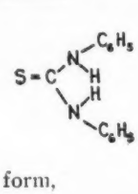
of oil and sulphide surface, by substituting for θ in the formula, we see that the surface tension between oil and sulphide is much less than the surface tension between water and sulphide. From the principle of minimum energy we should expect the sulphide-oil area, with the lower interfacial tension, to increase at the expense of the sulphide-water area with the higher interfacial tension. If we substitute in the formula the value of θ obtained with gangue and oil, it will appear that the interfacial tension between gangue and oil is higher than the interfacial tension between gangue and water. Therefore, in accordance with the principle of minimum energy, the oil will not spread on the gangue surface.

Recapitulating, we may then say that in the presence of water, due to differences in interfacial tensions, collecting oils function through preferential wetting of sulphide surfaces, and the reverse is true with gangue minerals.

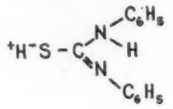
The soluble collectors are the collectors of modern practice. A statistical analysis[2] of a large number of soluble collectors has shown that they are characterized by the presence of a multivalent amphoteric element, combined in negative low-valent or reduced state. Further, it has been found that in most of these reagents the multivalent amphoteric element was either sulphur, occurring in the form of sulphur hydrate or with the hydrogen being replaced by an alkali or a metal; or nitrogen, in most cases occurring as part of an amino or diazo-group. Examples for the sulphur type are potassium ethyl xanthate,



and thiocarbanilid;



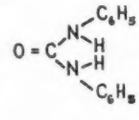
tautomeric form,



in which we find both nitrogen and sulphur in the forms mentioned in the foregoing. An example for the nitrogen type is diazo-amino-benzene,

$$C_6H_5 - N = N - \underset{H}{N} - C_6H_5$$

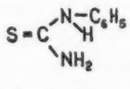
Taggart, Taylor, and Ince[3] have shown that if powdered galena is shaken in a solution of thiocarbanilid and then filtered, the filtrate shows abstraction of thiocarbanilid. The same authors showed that abstraction was localized in a definite part of the molecule by the following experiment: Powdered galena was shaken in a solution of carbanilid (thiocarbanilid with oxygen replacing sulphur)



and then filtered. The filtrate showed no abstraction. Evidently, the results of the two experiments indicate that sulphur determines abstraction. Experiments with thiocresol, $C_6H_4 \cdot CH_3 \cdot SH$, and cresol, $C_6H_4 \cdot CH_3 \cdot OH$, also lead to the same conclusion.

Taggart, Taylor, and Ince[4] showed further that collectivity was also localized in a definite part of the molecule by conducting the following experiments: A clean galena surface was treated in a solution of thiocarbanilid and then its behavior toward an air-bubble was tested. The bubble attached itself to the galena surface. Another clean galena surface was similarly treated in a solution of thiourea,

(thiocarbanilid minus the two phenyl groups), but this particle surface showed no attachment to an air bubble, although an abstraction test showed that there had been abstraction. Still another clean galena surface was treated in a solution of mono-phenyl-thiourea,



(thiocarbanilid minus one phenyl group), and this time the particle surface showed some attachment to an air bubble, and an abstraction test showed that there had been abstraction. Obviously, the indicated conclusion is that in thiocarbanilid the sulphur determines abstraction and the hydrocarbon or water-repellent group determines attachment to bubbles.

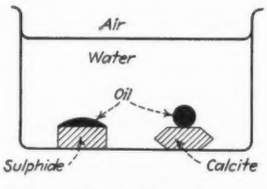


Fig. 5 — Illustrating that oils in presence of water show a preferential wetting of sulphide surfaces

Taggart, Taylor, and Knoll[5] and Taylor and Knoll[6] have shown that the mechanism of abstraction is chemical in nature, and, in the cases investigated, that it is a metathetical reaction. If powdered galena is shaken in distilled water and then filtered, the filtrate shows presence of sulphate ions and other sulphur-oxygen ions. If another portion of powdered galena is shaken in a solution of potassium ethyl xanthate and then filtered, the filtrate shows abstraction of xanthate ion, no abstraction of potassium ion, absence of lead ion, but an increase in concentration of sulphate ions and sulphur-oxygen ions over that obtained with galena in distilled water. A metathetical reaction is clearly indicated between an oxidized galena surface and potassium ethyl xanthate.

$$PbSO_4 + 2KEtX = Pb(EtX)_2 + K_2SO_4$$

A consideration of the solubilities of the compound involved gives more supporting evidence. Thus, $PbSO_4$ with a solubility of 43 mg. per liter reacts with KEtX to give $Pb(EtX)_2$ with a solubility of about half a milligram per

[2]A. F. Taggart, T. C. Taylor, and C. R. Ince: "Experiments with Flotation Reagents." *Trans.* A.I.M.E. (1930), Vol. 87, "Milling Methods," p. 285.

[3]*Ibid.*

[4]*Ibid.*

[5]Taggart, A. F.; Taylor, T. C.; and Knoll, A. F.: "Chemical Reactions in Flotation." *Trans.* A.I.M.E. (1930), Vol. 87, "Milling Methods," p. 217.

[6]Taylor, T. C., and Knoll, A. F.: "Action of Alkali Xanthates on Galena." *Trans.* A.I.M.E., Contr. No. 26 (1933).

liter. The solubility of lead sulphide (PbS) is about a third of a milligram per liter; therefore it seems that the success of collection, at least in the case of galena and KEtX, is dependent upon some oxidation of the mineral surface. The following experiments offer interesting data in support of this statement:

If galena is ground in an atmosphere of nitrogen, it will show an abstraction of KEtX which is considerably less than that obtained with galena which has been ground in the presence of oxygen. If the galena which has been ground in an atmosphere of nitrogen is allowed to stand in air for five minutes, it will give abstractions which approach the values obtained with galena ground in air. Tests on ball-mill waters show that, in grinding, the water is actually impoverished of oxygen. Again, if a galena surface which would ordinarily show contact with an air bubble after treatment with KEtX is treated in a solution of Na_2S, no contact develops. However, if this galena particle is washed in running water, and then replaced in KEtX solution, the surface will show attachment to an air bubble. Apparently, the oxygen dissolved in water reoxidizes the lead sulphide surface so that it may react with KEtX.

The common gangue minerals like quartz, the feldspars, and calcite give no abstraction and no collection when KEtX is used.

That these reactions are surface reactions may be shown by dissolving the surfaces of mineral particles which have been treated with KEtX. These experiments have given, in the case of galena treated in KEtX, a liquor which gave a test for xanthate ion.

Now, when a mineral surface is oiled, this surface becomes water-repellent. Therefore it seems that the active group of these soluble collectors simply supplies the chemical, rather than physical or mechanical, means of attaching an "oil" to the mineral surface. It follows, then, that when one of these collector molecules is brought in contact with a galena surface, the active part reacts with the metal of the sulphide surface, forming thereon a substantially insoluble compound and thereby becoming firmly anchored to the mineral. Therefore the hydrocarbon or water-repellent part of the molecule must be, against its own wishes as it were, in contact with water but ever ready to surround itself with air or oil at the expense of the water. This picture implies not only orientation, but also that the extent of reaction must go only so far as to provide a monomolecular layer. Evidence on this score is brought out by the fact that lead ethyl xanthate in bulk shows substantially no air-avidity. In other words, the proper functioning of soluble collectors implies a "forceful" subjection of the hydrocarbon or water-repellent part of the molecule to contact with water prior to introduction of air.

Using xanthates, Wark and Cox[7] have shown that the contact angle is the same for all minerals and for all collectors, provided the water-repellent part of the molecule of the xanthate is the same. Also, they have shown that the magnitude of the contact angle increases with increase in length of water-repellent group. Thus, using clean bornite surfaces, the contact angles obtained with potassium methyl xanthate [hydrocarbon group ($-CH_3$)], potassium ethyl xanthate ($-C_2H_5$), potassium normal propyl xanthate ($-C_3H_7$), and potassium normal butyl xanthate ($-C_4H_9$) were 50, 60, 68, and 74 deg., respectively. When galena, properly conditioned in the case of potassium methyl xanthate, was substituted for bornite, the same contact angles were obtained. This supplies additional evidence in support of orientation.

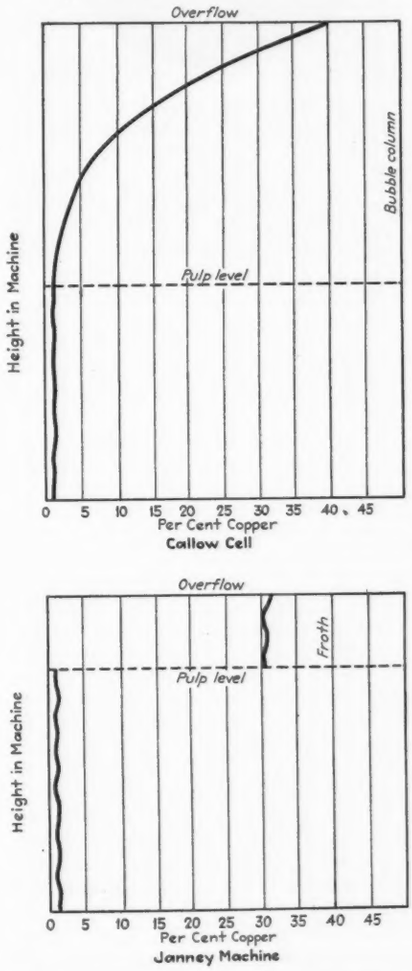
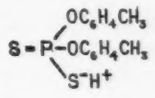


Fig. 6—Curves demonstrating that concentration in the Callow cell is effected in the bubble column and, in the agitation machine, in the pulp. (After Taggart.)

In addition to xanthates, phosphocresylic types of reagents



in which the hydrogen of the sulphurhydrate group may be replaced by an alkali, have found wide application in the flotation of copper minerals. The similarity between this type of reagent and the xanthates indicates that these reagents probably function also by metathesis.

Oleic acid and soaps (alkali salts of oleic acid, palmitic acid, and stearic acid) have also been used as collectors, especially in the flotation of non-metallics. Luyken and Bierbrauer[8] have shown that with galena, calcite, and apatite, sodium palmitate $CH_3(CH_2)_{14}COONa$ (active part, COONa) functions by reacting with the mineral surfaces to form lead palmitate and calcium palmitate, which are insoluble in water at the surface of galena and apatite, respectively.

Recapitulating, we may then say that soluble collectors function by forming substantially insoluble, water-repellent monomolecular films on the surface of the minerals to be floated while the other minerals remain unaffected. In the cases investigated, it seems that this filming is brought about by a metathetical reaction between the collector and the mineral surface. This is due to the fact that the compound resulting from this reaction is less soluble than the compound originally present at the surface of the mineral.

Aeration

Air or gas may be introduced in a flotation pulp in several ways. Thus, air may be bubbled through the pulp, or the pulp may be boiled, or subjected to a vacuum, or carbon dioxide may be generated in the pulp by reaction between an acid and a carbonate, or the air may be beaten into the pulp by rapid stirring. However, the first-named method utilizes a different mechanism of mineral-bearing froth formation than the other processes utilize.

If, according to Taggart,[9] samples of pulp are taken at different levels from a Callow cell, and from the spitzkasten of an agitation machine (Janney machine), and assayed, and then the results are plotted as in Fig. 6, we may conclude that in the Callow cell concentration is effected in the bubble column, whereas in the agitation machine concentration is effected in the pulp. If the ore being treated in the two machines is made up of dark sulphides and light gangue minerals, the bubble column will show a gradual color transition from light at the bottom to dark

[7] Wark, I. W., and Cox, A. B.: "Principles of Flotation—An Experimental Study of the Effect of Xanthates on Contact Angles at Mineral Surfaces." *Trans.* A.I.M.E., T. P. 461 (1932).

[8] W. Luyken and E. Bierbrauer: Mitt. Kaiser Wilhelm Institute für Eisenforschung; XI, 37 (1929).

[9] Taggart, A. F.: "Handbook of Ore Dressing." New York, 1927. John Wiley & Sons.

at the top; whereas the froth of the agitation machine will be uniformly dark from top to bottom.

The Callow cell is typical of the operation called pneumatic or bubble-column process, as concentration is effected in the bubble column; the agitation machine is typical of the operation called pulp-body process, inasmuch as the concentration is effected in the body of the pulp.

If an active bubble column is examined with a magnifying lens, one will see that all the mineral particles comprising the ore are falling, but one will also note that a sulphide particle will adhere to the bubble wall until the "south pole" of the bubble is reached, and then sometimes it will cling long enough so that several other particles may collect there, after which it will fall onto the bubble below and follow a similar course. However, the gangue particles, although falling on the bubble walls, will leave them at the "equator" and then fall through the liquid between bubbles and drop onto another bubble and follow a similar course. Fig. 7 shows, in addition to the conditions here described, typical paths of sulphide particles and gangue particles in a bubble column per unit of time. It will then be clear that the effect of a bubble-column operation is to retard the fall of sulphide particles relatively to gangue particles. By regulating the mean rising rate of bubbles, by the air supply, so that it is intermediate between the mean falling rates of sulphide particles and gangue particles, the former will have a resultant rise and the latter a resultant fall. Thus, separation is effected in the bubble column.

The agitation process is not capable of direct observation. An examination of the froth shows that the bubbles are heavily coated with minerals, and also that the bubbles are very small as compared to the bubbles of the bubble-column process. A microscopic examination of bubbles taken from the froth shows that the mineral particles are in the air-water interface. Fig. 8 is a photomicrograph of a bubble taken from an agitation process. The arrow points to a mineral-particle surface which has a globule of water standing on it.

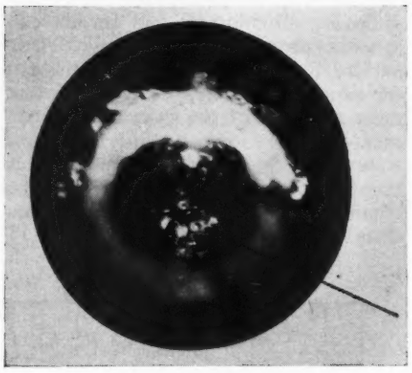


Fig. 8—Photomicrograph of bubble from agitation process. See text

Clearly, the surface must be in the air-water interface or the globule of water could not be there. Therefore, the particle is held to the bubble by the surface tension of the air-water interface.

That a bubble from an agitation froth is heavily coated with minerals seems to be brought about by the following: When a mineral particle becomes attached to a bubble due to gravity, it will move down to the "south pole" of the bubble. When other particles become attached to the same bubble, again due to gravity, they will move down to the "south pole" and tend to crowd off the bubble the original particle held there. If this original particle is being held by a force great enough in magnitude to withstand not only the downward force, as represented in Fig. 3, but also the additional downward force caused by the "loading" of the additional particles, then the particle will remain attached to the bubble and support the others. Eventually, if this "building up" continues, the particles will key one another into position and an armored bubble will be obtained. In a bubble from an agitation froth, we know that the force holding particles is the surface tension of an air-water interface contaminated with a frothing oil. Therefore, the fact that in a bubble from a bubble-column operation there is no substantial "building up," and the fact that we can observe sulphide particles falling off the "south pole" of bubbles, seem to imply that in this case the force holding particles on bubbles is less than the surface tension of an air-water interface contaminated with a frothing oil.

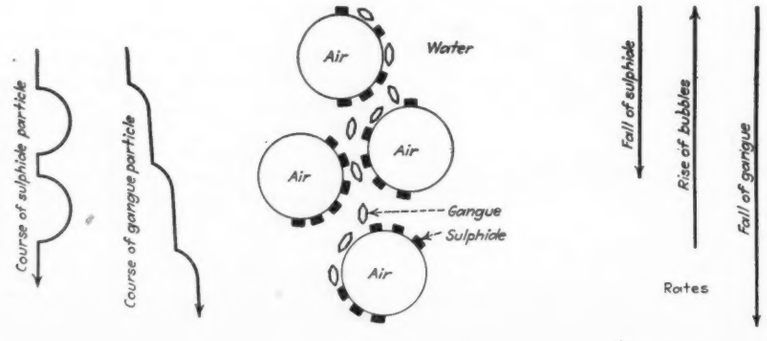
Taggart, Taylor, and Ince[10] have shown that the froth from a bubble-column process contains more frothing oil than the froth from an agitation process. Therefore, it seems that the lesser force with which a particle is held to a bubble in a bubble-column process may be due to either the larger amount of air-water interfacial tension-lowering contaminant which would lower this interfacial tension still more, or it may be due to the possibility of the particle being held at the oil-water interface, with a surface tension much lower than that of an air-water interface contaminated for proper frothing operation.

The following experiment described by Taggart[11] is interesting in this connection: Some ground ore is mixed with water in a test tube and a few cubic centimeters of Nujol are added. Then the test tube is closed with a clean cork. The mixture is shaken and then observed with a low-power microscope. Examination will show small globules of oil with sulphides at the water-oil interface. Apparently, the sulphides will be held there by the oil-water interfacial tension. If a minute amount of steam-distilled pine oil is added[12] and the shaking is repeated, microscopical observations will show that air is now included in the oil globules with the sulphide particles still at the oil-water interface. Continued shaking will cause progressive thinning of the oil film around the air bubbles until it will be no longer visible at the magnification employed. Fig. 9 shows the various stages of the experiment. Because of the fact that, as long as the oil was visible, the sulphide particles appeared to be carried at the oil-water interface, it seems reasonable to assume that the sulphide particles remain at the oil-water interface.

In view of the results of this experiment and the fact that the surface tension of the overflow liquid of a frothing operation is upward of 60 dynes per centimeter, whereas the surface of an oil-water interface is probably not more than half that figure, it seems reasonable to assume that in a bubble from a bubble-column the particles are held at the oil-water interface; and we know that in a bubble from an agitation process the particles are held at the air-water interface. Therefore, the difference in forces with which particles are held to the two bubbles seems due to the difference between the two interfacial tensions involved.

In the agitation process, attachment of floatable particles to bubbles seems to be brought about by precipitating air

Fig. 7—Typical paths of sulphide particles and gangue particles in bubble column per unit time



[10]See footnote No. 2.
[11]See footnote No. 9.
[12]Article on "Frothing," April issue *E.&M.J.*

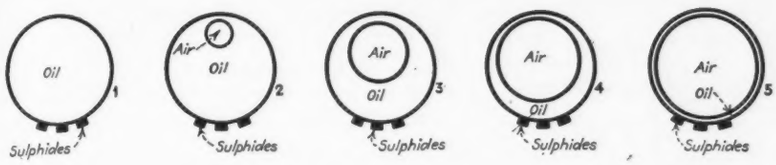


Fig. 9—Stages of experiment to support assumption that sulphide particles remain at oil-water interface. See text

from solution on oiled sulphide particles. The following experiment is interesting in this connection: If a clean piece of galena is placed in water under vacuum, nothing will happen. If, however, the galena is oiled, and the operation is repeated, then bubbles may be seen to form on the oiled galena surface and grow to considerable size. Inasmuch as no bubbles were present at the beginning, nor were any introduced, the bubbles must have come by precipitation from solution in the water.

Now, the blades of an impeller in an agitation machine, revolving through water, create a vacuum behind them which has been measured and which causes air dissolved in the water to precipitate out of solution. At the same time, air which is introduced in the water by cutting, by the blades, of the vortex created by stirring and of air bubbles introduced in the water by the turbulence at the surface of the water, is subjected to super-atmospheric pressure in the zones in front of the blades and is thereby forced in solution. The agitation process, therefore, is a continuous vacuum process which may be operated at atmospheric pressure.

Recapitulating aëration: Flotation processes may be divided into two classes; namely, bubble-column processes and pulp-body processes. Flotation machines which embody characteristics of bubble-column operation are the Callow cell, the MacIntosh machine, and the Forrester machine. Flotation machines which embody characteristics of pulp-body operation are the Janney machine and the Mineral Separation machine. Flotation machines which embody characteristics of both types of operation are the Denver Sub-A, the Fagergren, and the Ruth.

Mahr Tunnel Completed

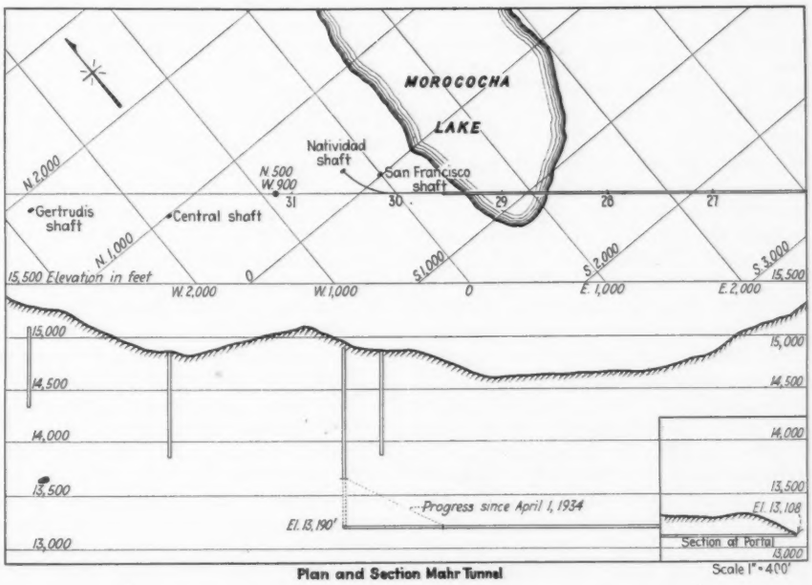
Fast Driving by Cerro de Pasco Under Bad Conditions

THE Cerro de Pasco Copper Corporation advises that on April 30 the Mahr drainage tunnel to its Morococha mines was completed to a point directly beneath Natividad shaft, a total distance from the portal of 30,564 ft., and that until the connection with this shaft has been made the work on the tunnel will be suspended. Later on, the tunnel may be extended to the Central shaft and possibly to other workings. The accompanying sketch shows the general position of the tunnel with relation to the various shafts. Although the correctness of the survey has never been in doubt, the work having been re-checked many times (only recently by the aid of an electric arc a sight exceeding 19,000 ft. was made on a long tangent), nevertheless, to be doubly sure of the survey and to facilitate and expedite the drainage of the Natividad shaft while being sunk and raised to connect with the tunnel, a diamond-drill hole is being put down from the shaft to the tunnel level, about 370 ft.

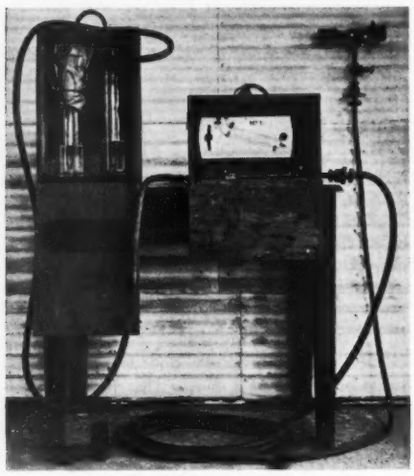
Despite adverse conditions, the work of driving the tunnel has been completed in remarkably short time. The speed increased notably during the past year, or since April 12, 1933, when the heavy flow of water occurred, as described in *Engineering and Mining Journal* for October, 1933. Driving was resumed on July 16 in the main tunnel; that is, as soon as the water had subsided sufficiently to give access to the face. Since then, in 9½ months, the advance has been 7,381 ft., an average of 782 ft. per month, or about 26 ft. per day. In March the advance was the greatest of any month—1,110 ft., and in the last six days of March it was nearly 40 ft. per day. The greatest advance for any single day was 50.4 ft. on Feb. 27, 1934.

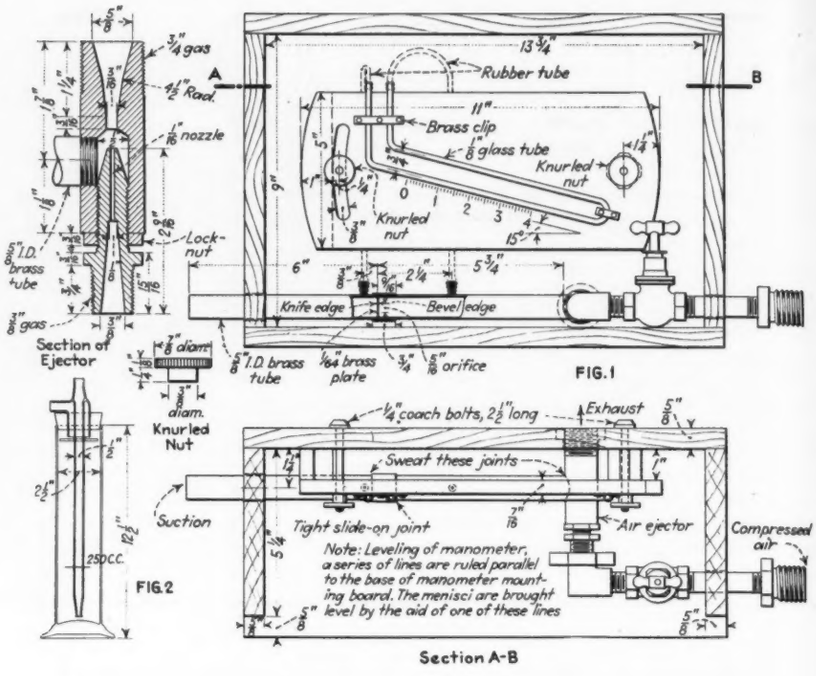
The flow of water from the portal increased from 18,000 g.p.m. in early April, 1933, to 40,000 at the portal in April, 1934, one year later. Taking into consideration the high altitude, 13,108 ft. at the portal of the tunnel, and the facts of the heavy flow, often covering the haulage tracks for many thousand feet to a depth of over 16 in., and the great distance of between 5 and 6 miles from the portal to the face in the last few months, the rate of driving was not only remarkable but almost incredible. Harold Kingsmill, general manager, writes that the excellent footage achieved in the past year was entirely without the aid of expensive mucking machines or elaborate drill carriages and that the organization is proud that the scraper loader, built and adapted to the size of the tunnel on the job, was entirely a home invention, and that the use of old-fashioned crossbars in the face instead of drill carriages was found to be a real time-saver.

As the tunnel advanced the demand on the mine pumps decreased. In April, 1933, they were handling 12,600 g.p.m. A year later the water handled had dropped to 7,100 g.p.m., so that as the tunnel advanced, a substantial saving was being made in pumping costs. As soon as the Natividad mine shaft is completed, and the drainage connection to the tunnel has been made, practically all pumping can be done away with.



Plan and Section Mahr Tunnel Scale 1" = 400'





Assembly of dust-sampling apparatus shown in drawings at right. Right—Fig. 1, Air ejector and meter for sampling dust in mine air by gravimetric method. Fig. 2, Modified Greenburg-Smith impinger

Sampling Mine Air For Dust

Arnold B. Black

Chief Surveyor,
Broken Hill South, Ltd.,
Broken Hill, N.S.W.

ALTHOUGH the lead-silver-zinc sulphide ores of Broken Hill, New South Wales, contain little free silica, a low dust content of the mine air is nevertheless the desirable condition. To achieve this, the suction fan at the South Mine draws 125,000 cu.ft. of air per minute from the mine, equal to 400 cu.ft. per man underground per minute. The air currents are kept under observation and the downcast air is distributed to best advantage. At this mine 30,000 long tons of ore per month is extracted. At half-yearly intervals, temperature and dust-sampling surveys are made. Two methods of dust sampling, here described, are used: one giving a gravimetric result—milligrams of dust per cubic meter; and the other volumetric—particles of dust per cubic centimeter.

The average stope temperature in June, 1933, was 71.7 deg. F. dry bulb, and 70.2 deg. F. wet bulb. Average dust content of the stope air was 1.63 mg. per cubic meter and 184 particles per cubic centimeter. The gravimetric sample results, since December, 1922, are shown in the graph, Fig. 4.

Apparatus used in gravimetric sampling is shown in Figs. 1 and 2. The box shown in Fig. 1 contains an air ejector and orifice flowmeter, together with the necessary rubber tubes, air hose, and fittings. The ejector, operated by compressed air from the supply pipes in the working places, draws a sample of air through the sample bottle shown in Fig. 2. Each side of the orifice meter is connected to an inclined manometer contained in the box. The sample bottles are of the Greenburg-Smith impinger type (Fig. 2). Before taking them underground, 250 c.c. of filtered distilled water is put into each bottle, the tubes of which are plugged and the entire top of which is covered with a clean brown paper bag. The assembly of this sampling outfit is shown in the cut at the left of Figs. 1 and 2.

Apparatus for volumetric sampling consisted of a Kotze konimeter, Fig. 3, together with glass slides and a microscope with a ruled grid in the eyepiece to facilitate counting the dust particles.

Procedure is as follows: To calibrate the flowmeter, a cylindrical tank, of a capacity of 11 liters per inch and fitted with a gage glass, is connected by rubber tubing to the exhaust end of the suction apparatus. A water gage is connected in parallel with the rubber tubing. The sampling rate used is 50 liters per minute. A series of calibration tests are made, on the flowmeter, as nearly as possible at this rate. Water is run out of the tank for one minute, during which time the water-gage pressure is read and the movement of the water column in the inclined manometer noted. This test is repeated until sufficient observations have been made. Using the water-gage pressure readings, the water quantities are converted to air volumes at atmospheric pressure. A graph is then plotted, air volumes against manometer readings, and the correct reading for 50 liters of air per minute is obtained. It is not material to the success of the calibration that a sample bottle be placed in the circuit.

In sampling the working-place air by gravimetric means the suction apparatus, placed in a suitable position, near the miners' faces, is connected to the air main and a sample bottle. The air is turned on until the manometer reading is correct, and sampling is continued for one hour, during which 3 cubic meters of air are passed through the bottle. The impingement of the air stream on the bottom of the bottle, and the scrubbing action of the water, remove and collect the dust from the air sample. On completion of the test the bottle is again covered and sent to the assay office for determination of the contained dust. This is done by filtering the water through a double filter paper, igniting the filter, and weighing the residue, making due allowance for the paper ash. The result is expressed in milligrams of dust per cubic meter of air.

When volumetric means are used, at least four dust spots are obtained, during the sampling period, on a glass slide by the Kotze konimeter. These spots represent a measure of the dust in

5 c.c. of air. On returning to the surface each spot is examined in the microscope. using a magnification of 180. Two sectors of 18 deg. each are counted, and the results obtained are reduced to particles of dust present per cubic centimeter.

The Greenburg-Smith impinger sample bottle is an efficient dust collector, tests with tobacco smoke showing an efficiency of over 90 per cent. The volume of air sampled is large—about 30 per cent of the working end of a development heading, and about 1 per cent of the immediate working area in a stope 40 ft. wide. On the other hand, the konimeter has a low efficiency as a dust collector and takes but a very small sample.

It is attractive to consider dust in number of particles rather than in milligrams, and efforts, as yet unsuccessful, have been made to count the particles in a portion of the water from the Greenburg-Smith sample bottle. The sulphide dust particles tend to come together in groups, rendering accurate counting difficult. This trouble, to a lesser extent, is also experienced when counting the konimeter dust spots.

For the reasons given in the foregoing, the gravimetric method has preference at the South Mine. The volumetric determination, by the konimeter, is nevertheless made, and is useful for comparison with the results obtained in other fields using the method.

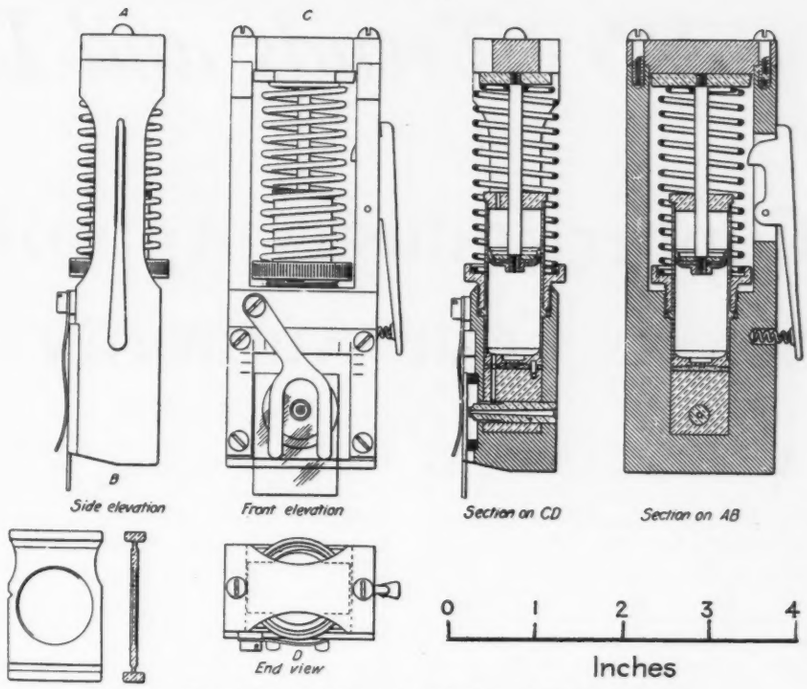
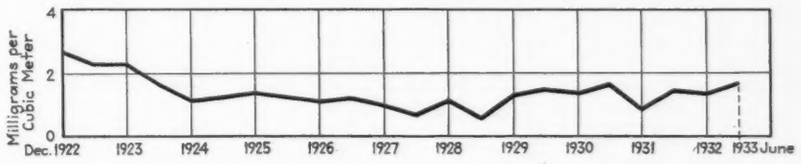


Fig. 3—Elevations, sections, and end view of Kotze konimeter.
Below, Fig. 4, Graph showing low dust content of air of South mine



Ground Movement—Subsidence

Two Interesting Studies From Arizona Camps

NO HARD AND FAST RULE can be established in regard to breaking and subsidence of the surface over mined-out areas, according to W. H. Kantner, mining engineer for Phelps Dodge Corporation, at the recent meeting of the American Institute of Mining and Metallurgical Engineers, in New York, with reference to porphyry caving blocks. Too many outside factors enter the problem. One such block contained the southeast extension of the so-called East orebody at Bisbee—a low-grade disseminated sulphide deposit in granite porphyry. It was irregular in outline and extended in depth from 425 ft. to 1,050 ft. below the surface. Above it the surface was fairly regular in contour.

Stoping began early in 1925, and in the following year the surface was watched closely for deformation, being carefully surveyed. Several lines of fixed points were put in to permit measurement of any movement, as a means of protecting the buildings and railroad.

Within two years the surface had sunk a maximum of 6 ft., and cracking was pronounced. As work progressed, the depression deepened, the cracking extending outwards in most directions and becoming larger. The railroad was rerouted. Then several holes opened, which gradually increased in depth and circumference, and new ones appeared until there were ten in all. Eventually mining was completed, the volume of ore taken out measuring on Jan. 1, 1932, 28,250,000 cu.ft. and the surface subsidence equaling a volume of 14,614,500 cu.ft., this giving a ratio of 1.933 cu.ft. mined to 1 cu.ft. of subsidence. Outside of the holes, the maximum depth of the depressed area was 70 ft. Thereafter subsidence continued, gradually slowing up, until it attained 78 ft. depth and now appears likely to cease sometime this year.

Subsidence at the United Verde Copper mine, at Jerome, Ariz., presents a problem different from that at relatively shallow porphyry deposits, according to C. E. Mills, mine superintendent. Here the ore deposits are of the massive-sulphide, schist-replacement type, a structural anticline having localized the sulphide. Horizontally, the mineralized zone varies from 200,000 to 400,000 sq.ft. in area and extends from surface to the lowest levels at 50 to 75 deg. dip.

Although a study of the structural condition of this sulphide mass may show definitely the reasons for the subsidence that occurs, to predict the extent of further settlement in the next decade or two, according to Mr. Mills, is harder. It is almost impossible with a deep-seated or vein-type orebody extending several thousand feet in depth. Should the conventional method of determining the angle of joints or planes of weakness be used and applied to the 3,000 level (the lowest workings at the United Verde), the surface areas involved would be so extensive that shafts and plants could not be located on the property, and development drifts and haulageways to the orebody would be impracticable.

Copper Industry Approves Code and Selects Code Authority

APPROVAL of a code of fair competition for the copper industry was finally effected on April 21, following nine months' deliberations. The code is essentially that submitted early in April by the industry, except that a new Article VII, dealing with marketing provisions, was substituted by the Administration for that contained in the industry's proposed code.

A Code Authority of eleven members, representing the several groups in the industry, is provided for (see Article VI). At a meeting held in New York on May 1, the following representatives for the various groups were chosen:

Group A—E. T. Stannard, president, Kennecott Copper Corporation. Cornelius F. Kelley, president, Anaconda Copper Mining Company. Louis S. Cates, president, Phelps Dodge Corporation.

Group B—Albert E. Petermann, vice-president, Calumet & Hecla Consolidated Copper Company. George Adams Ellis, director, United Verde Copper Company.

Group C—Bernard N. Zimmer, vice-president, American Metal Company. Francis H. Brownell, vice-president, American Smelting & Refining Company.

Group D—Clinton H. Crane, president, St. Joseph Lead Company. Pope Yeatman, consulting mining engineer, Yeatman & Berry.

Group E—W. A. Anderson, vice-president, John A. Roebling's Sons Company.

Group F—W. M. Goss, secretary, Scovill Manufacturing Company.

The following were elected officers of the Code Authority (see Section 4, Article VI): E. T. Stannard, chairman; R. R. Eckert, secretary-treasurer and sales clearing agent.

The text of the copper code, with the "New Article VII" substituted by the Administration, follows:

ARTICLE I

Purposes:

To effectuate the policies of Title I of the National Industrial Recovery Act the following provisions are established as a Code of Fair Competition for the Copper Industry, and shall be the standard of fair competition for such industry and binding upon every member thereof.

ARTICLE II

Definitions:

As used in this Code, words and phrases have the following meanings:

1. The term "Copper Industry" or "Industry" includes the mining, production, treatment, and/or sale of copper in the United States, but excludes (1) the fabrication thereof or the sale thereof in fabricated form, and (2) such minor operations either in whole or in part in relation to secondary copper as will not jeopardize or materially affect the purposes of the Code, the exclusion of which may be specifically approved by the Administrator.

2. The term "Member of the Industry" or "Member" means anyone engaged in the Copper Industry or in one or more of the phases involved therein.

3. The term "Copper" includes lake copper, electrolytic copper, casting and best select (fire-refined) copper of whatever grade, bessemer, blister and black copper of whatever grade, but does not include fabricated copper in any form. The term "Copper" does not include casting copper produced from scrap by fire-refining suitable for casting purposes in foundry use and for copperizing steel but not suitable for rolling or drawing or for use in copper or brass sheet, wire, tube or rod mills.

4. The term "Primary Copper," as distinguished from secondary copper and byproduct copper hereinafter defined, means new copper derived or procured after the effective date of the Code from mining or metallurgical operations in the United States, including copper commonly known as "Custom Copper" produced from the same sources as primary copper.

5. The term "Secondary Copper" or "Secondary Metal," as distinguished from primary copper and byproduct copper as herein defined, means that copper produced in the United States by smelters and refiners by re-working scrap copper, scrap brass, and scrap alloys containing copper, excluding any copper classed as copper stocks on the effective date of this Code.

6. The term "Byproduct Copper" means copper produced or recovered incidental to or as a byproduct in the treatment and recovery of other metals or materials, from ores, concentrates or iron pyrites.

7. The term "Custom Copper" means primary copper produced by custom smelters and/or refiners from purchased ores, concentrates, matte or blister copper derived from primary sources.

8. The term "Fire-Refined Copper" means copper produced from copper-bearing material, either primary or secondary, through treatment by fire for the purpose of removing impurities.

9. The term "Lake Copper" means fire-refined primary copper produced in the State of Michigan.

10. The term "Primary Producer" means any member of the industry who is a producer of primary copper.

11. The term "Custom Smelters and/or Refiners" means those members of the industry, sometimes hereinafter referred to as "Secondary Producers" or "Producers of Secondary Metal," who have facilities for production of electrolytic copper and who receive primary ores, copper concentrates, blister copper, scrap copper, junk copper and/or byproduct copper for processing into copper, either charging the shipper a treatment charge and returning the resulting copper to the shipper or purchasing the material outright and selling the copper produced therefrom to consumers.

12. The term "Production" in relation to primary copper means the resulting finished merchantable product derived from the treatment of ores, concentrates and other copper-bearing or partly processed material together with any substantial increase in copper-bearing material above ground or removed from the mine, without duplication. The intent of this method of computation as to primary copper production is to correlate actual mine production with

LOUIS S. CATES
President, Phelps Dodge Corporation
Code Authority Member

production as defined and as limited herein, and without allowing an intermediate accumulation of ores, concentrates or partly processed material.

13. The term "Intake," in relation to secondary copper means the tonnage of secondary copper priced each day by Custom Smelters and/or Refiners; not including any pricings of custom copper and/or of byproduct copper.

14. The terms "Stocks of Copper," "Copper Stocks" or "Stocks" mean stocks or inventories of copper, as defined, in the United States, in the hands of members of the industry and their owned or controlled subsidiaries, excluding bessemer, blister and black copper and copper in bond.

15. The term "Electrolytic Copper Wire Bars" or "Electrolytic Wire Bars" means electrolytically-refined copper cast into standard shapes suitable for rolling and drawing in copper wire and rod mills.

16. The term "Productive Capacity" of any primary producer, for the purposes of this Code means the tons of copper such producer is stated to be able to produce with its present plant and equipment in a period of one year, but capacities as herein stated are relative and do not necessarily signify the maximum which any member

of the industry is able to produce in a single year.

17. The term "Selling Price" as used herein means the price at which electrolytic wire bars of standard size are sold on the basis of Connecticut Valley delivery, and shall be subject to applicable differentials for delivery at other points, and for the other shapes and grades.

18. The term "Employee" includes anyone engaged in the industry in any capacity receiving compensation for his services, irrespective of the nature or method of payment of such compensation, except a member of the industry.

19. The term "Employer" includes anyone by whom any such employee is compensated or employed.

20. The term "Apprentice" means an employee who is regularly engaged in learning a trade under a course of training designed to advance him systematically in the various operations of such trade to become a competently skilled mechanic.

21. The term "Northeastern Wage District" is defined as comprising all states east of the Mississippi River and north of the Ohio River, and north of the states of West Virginia, Maryland, Delaware, except the states of Michigan, Wisconsin and Minnesota. The term "Southeastern Wage District" is defined as comprising all states east of the Mississippi River, and south of the states included in the Northeastern Wage District except West Virginia. The term "Great Lakes Wage District" comprises the states of Michigan, Wisconsin and Minnesota, and the term "Southwestern Wage District" comprises the states of Arizona, New Mexico, and Texas, and the term "Northwestern Wage District" comprises all states west of the Mississippi River, and the

CORNELIUS F. KELLEY
President, Anaconda Copper Mining Company
Code Authority Member

Territory of Alaska, except the three states in the Southwestern Wage District.

22. The term "Owning and Controlling" or similar terms with reference to a subsidiary company means the ownership either directly or indirectly of a majority of the voting capital stock of the subsidiary company.

23. The term "Affiliate" means (1) a company in which another company has a substantial interest through the ownership of its voting capital stock, but less than a majority thereof, or (2) a company under common ownership or control with respect to one or more other companies.

24. The terms "President," "Act" and "Administrator" mean, respectively, the President of the United States, the National Industrial Recovery Act and the Administrator of Title I of said Act.

25. The term "Code Authority" means the authority provided for under Section 1 of Article VI hereof.

26. The term "Fabricator" means one engaged in the processing of copper for the purposes of sale in fabricated form.

27. The term "Consumer" means anyone who purchases copper for fabrication or other manufacturing purposes.

28. The term "Association" as used herein means the United States Copper Association, an unincorporated association having its principal offices at 33 Rector Street, New York, N. Y.

29. The term "United States" means the part of the United Sttaes on the North American Continent.

30. The term "Effective Date" is the date upon which this Code becomes operative and effective.

ARTICLE III

Hours of Labor:

Maximum Hours:

1. On and after the effective date of this Code no employee shall be permitted to work in excess of 40 hours per week, averaged over a three-month period, or in excess of 8 hours in any 24-hour period except as herein otherwise provided. Every employer at the end of each quarter shall report to the Code Authority, in such detail as may be required by it or by the Administrator, any action taken by the employer in connection with the averaging feature herein provided, giving the number of man-hours so worked, the reasons therefor and the ratio which such man-hours bear to the total number of man-hours worked during said quarter. Such report shall be transmitted by the Code Authority to the Administrator. The Administrator may, at his discretion, appoint an impartial investigator to review conditions in the industry concerning the averaging provisions herein. Such investigator shall contact employers and employees and, on completion of his review, shall report to the Administrator and forward a copy of such report to the Code Authority.

Hours for Clerical and Office Employees:

2. No person employed in clerical or office work shall be permitted to work in excess of 40 hours per week, except that during any one week in a one-month period such employee shall be permitted to work a maximum of 48 hours in any such week, and except as herein otherwise provided. A normal day shall not exceed 8 hours.

Exceptions as to Hours:

3. The limitations as to hours of labor specified in Sections 1 and 2 of this Article III shall not apply to the following:

(a) To employees engaged in emergency maintenance, or emergency repair work, involving breakdown or protection of life or property; provided that in such special cases one and one-half times the normal wage rate for any employee so employed shall be paid for all hours worked in excess of 8 per day, or 40 per week. Such special cases, however, shall be reported to the Administrator through the Code Authority.

(b) To outside salesmen, nor to persons in an executive, managerial, technical, technical engineering, or supervisory capacity, who receive $35.00 or more per week.

(c) To hoistmen, powerhousemen, and pumpmen, who may be permitted to work a total of 48 hours per week.

(d) In the case of operations with three shifts in a 24-hour period where only in order to change shifts, it is necessary for employees to work more than 8 hours in one 24-hour period, the provisions concerning working in excess of 8 hours in any one 24-hour period shall not apply.

(e) In the case of shutdown properties or other special situations which may require modification of Sections 1 and 2 of Article III, the Administrator on request of the member of the Industry and after investigation and such public hearing as he may deem necessary may make special rules and modifications.

(f) To necessary clerical help that must work concurrently with employees described in Section 1 hereof and/or (a) to (d) inclusive of this Section 3, which clerical help may be permitted to work not in excess of the number of hours which such employees shall work.

Employment by Several Employers:

4. No employer shall knowingly permit any employee to work for any time which, when totaled with that already performed with another employer or employers in this Industry, exceeds the maximum permittted herein.

ARTICLE IV

Wages:

Minimum:

1. The minimum wage rates (except as hereinafter otherwise provided) for this Industry for the various districts shall be not less than as follows:

(a) Great Lakes Wage District—
Surface Labor, 32½c. per hour.
Underground Labor, 37½c. per hour.
(b) Northeastern Wage District—
Surface Labor, 37½c. per hour.
(c) Southeastern Wage District—
Surface Labor, 35c. per hour.
(d) Southwestern Wage District—
Surface Labor, 30c. per hour.
Underground Labor, 45c. per hour.
(e) Northwestern Wage District—
Surface Labor, 40c. per hour.
Underground Labor, 47½c. per hour

provided, however, that minimum wage rates in effect in any district on March 1, 1934, which were above the minimum specified herein for that district shall in no case be reduced; and provided further, that the underground rate in the Ray District of Arizona shall be not less than 38c. per hour.

Clerical and Office Employees:

2. No accounting, clerical, office, sales or service employee in any office shall be paid less than at the rate of $18.00 per week; provided, however, that office boys and girls and messengers shall be paid not less than at the rate of 80% of the minimum hereinabove specified; and provided further that the number of such boys and girls and messengers so paid shall constitute not more than 5% of the total number of such employees of any one office of any one employer, but in any case such employer shall be entitled to employ one such employee at not less than such reduced rate.

Wages Above Minimum:

FRANCIS H. BROWNELL
Vice-President, American Smelting & Refining Company
Code Authority Member

3. If an equitable adjustment of the differentials in the wage rates above the minimums fixed in this Code has not been made since July 1, 1933, there shall then be such adjustment, if necessary, made within 60 days from date of the approval of this Code. Such equitable adjustment shall mean that the differentials in amount existing prior to the formulation of this Code shall be maintained for employees other than persons enumerated in Article III, Section 3, paragraph (b), provided, however, that in no event shall hourly rates of pay be reduced.

Handicapped Persons:

4. A person whose earning capacity is limited because of age or physical or mental handicap may be employed on light work at a wage below the minimum established by this Code if the employee obtains from the State Authority designated by the United States Department of Labor a certificate authorizing such employee's employment at such wages and for such hours as shall be stated in the certificate; such Authority shall be guided by the instructions of the United States Department of Labor in issuing such certificates. Each employer shall file a list of such persons employed by him, with the Code Authority.

Method of Wage Payment:
5. When due, an employer shall make payment of all wages in lawful currency or by negotiable check therefor, payable on demand. No employer shall withhold wages unless so required by law. Wages shall be exempt from any payments for pensions, insurance or sick benefits other than those voluntarily paid by the wage earners or required by State Law. Wages shall be paid at no greater interval than every semi-month, and salaries at no greater interval than every month.

Piece Work Compensation — Minimum Wages:
6. This Article establishes a minimum rate of pay which shall apply, irrespective of whether an employee is actually compensated on time rate, piece work, or other basis.

Apprentices:
7. Employment of apprentices at rates of compensation below the minimum provided herein shall be permitted where they are apprenticed to an employer under any apprentice system established and maintained by such employer. No employer shall employ apprentices in number exceeding 10% of the total number of skilled craftsmen of their special class employed by such employer except that each employer shall be entitled to employ at least one such employee for each special class.

ARTICLE V

General Labor Provisions

Child Labor:
1. On and after the effective date, no person under 18 years of age shall be employed, in the Copper Industry except in clerical, office, sales, service, technical and engineering departments, and no person under 16 years of age shall be employed in any capacity.

Provisions from the Act:
2. (a) Employees shall have the right to organize and bargain collectively through representatives of their own choosing, and shall be free from the interference, restraint, or coercion of employers of labor, or their agents, in the designation of such representatives or in self-organization or in other concerted activities for the purpose of collective bargaining or other mutual aid or protection;

(b) No employee and no one seeking employment shall be required as a condition of employment to join any company union or to refrain from joining, organizing, or assisting a labor organization of his own choosing; and

(c) Employers shall comply with the maximum hours of labor, minimum rates of pay, and other conditions of employment, approved or prescribed by the President.

Reclassification of Employees:
3. No employer shall reclassify employees or duties of occupations performed or engage in any other subterfuge for the purpose of defeating the purposes or provisions of the Act or of this Code.

State Laws:
4. No provision in this Code shall supersede any State or Federal Law which imposes on employers more stringent requirements as to age of employees, wages, hours of work, or as to safety, health, sanitary or general working conditions, or insurance or fire protection, than are imposed by this Code.

Standard for Safety and Health:
5. Every employer shall make reasonable provision for the safety and health of his employees at the place and during the hours of their employment. Standards of safety and health for each division of the industry shall be submitted to the Administrator within six months after approval of the Code.

Posting:
6. All employers shall keep posted complete copies of the Labor Provisions of this Code and all amendments thereto in conspicuous places accessible to employees.

Company Town and Stores:
7. No employee, other than maintenance or supervisory men, or those necessary to protect property, shall be required, as a condition of employment, to live in any house owned by or rented from his employer. No employee shall be required, as a condition of employment, to trade at any store owned or specified by an employer.

ARTICLE VI

Administration Code Authority:

1. Membership:
A Code Authority to supervise the administration and enforcement of the Code is hereby created which shall consist of eleven members to be selected in the following manner:

(a) Three members, one to be appointed by each of the three largest primary producers as shown by figures filed with the Administrator by the United States Copper Association, January, 1934.....3

(b) Two members, to be elected by all other primary producers 2

(c) Two members, to be elected by custom smelters, refiners and other producers of secondary copper subject to the provisions of this Code.....2

(d) Two members, only one of whom may be connected with a member of the Industry; such members to be appointed upon the written designation of six members of group (a), (b), and (c), of which six, two shall be the members elected under (c) 2

(e) One member, to be appointed by the Supervisory Agency of the Wire and Cable Subdivision of the Electrical Manufacturing Industry 1

(f) One member, to be appointed by the Code Authority of the Copper and Brass Mill Products Industry 1

Total 11

The Administrator, in his discretion, may appoint not to exceed three members without vote, and without compensation from the Industry to cooperate with the Code Authority in the Administration of the Code, and to serve for such term as the Administrator may determine. Any member of the Industry may appoint a representative to attend meetings of the Code Authority but such representative shall have no vote.

Save as otherwise provided in this Code all action taken by the Code Authority shall be effective only upon the affirmative vote of six (6) voting members of the Code Authority.

2. Manner of Election or Appointment of Members:
Voting members of the Code Authority shall be appointed by each unit having the right of appointment or by each group in the manner specified, or if not specified, then as may be determined by the group, or failing of such determination, by some equitable method of selection approved by the Administrator, and shall hold office for a term of one year, or such shorter period as the appointing group may designate, or until their successors are elected and qualified.

Each unit or group may fill any vacancy at the expiration of terms of office or when vacancies otherwise occur. Each unit or group may name one or more alternates for each of its members of the Code Authority to act in the absence of any such member.

With respect to representation on the Code Authority each company, together with its owned and/or controlled subsidiaries or affiliates, shall be treated as one entity, and only one representative of such entity shall be eligible to membership on the Code Authority at one time.

In order that the Code Authority shall at all times be truly representative of the Industry and in other respects comply with the provisions of the Act, the Administrator may prescribe such hearings as he may deem proper; and thereafter if he shall find that the Code Authority is not truly representative or does not in other respects comply with the provisions of the Act, may require an appropriate modification in the method of selection of the Code Authority.

3. General Provisions:
(a) Nothing herein contained shall be deemed to constitute the members of the Industry partners for any purpose. No agreement hereto or acquiescence in the provisions hereof shall be deemed the agreement with or acquiescence in any statement of fact herein by any member of the Industry, and in particular as regards the respective productive capacities or production quotas of the primary producers. Accordingly, any member of the Industry may agree to the provisions hereof or acquiesce herein on the understanding that the Code is and shall continue an emergency measure, and that for all purposes the provisions hereof shall expire on June 16, 1935, and further that any such member shall not be prejudiced in any manner or for any purpose after the expiration of the term of this Code by reason of any agreement hereto or acquiescence in the provisions hereof.

(b) Nothing herein contained shall constitute the members of the Code Authority or their alternates, partners for any purpose. Nor shall any member of the Code Authority be liable in any manner to anyone for any act of any other member, officer, agent or employee of the Code Authority, nor shall any member of the Code Authority, exercising reasonable diligence in the conduct of his duties hereunder, be liable to anyone for any action or omission to act under this Code, except for his own willful misfeasance or nonfeasance.

4. Organization:
The Code Authority shall select a Chairman, Secretary, Treasurer, Sales Clearing Agent, and such other officers as it may deem necessary. It may appoint committees, the members of which need not be members of the Code Authority, to perform administrative duties hereunder; provided, however, that it shall not delegate to any such committee any specific authority and power granted to it under the provisions of the Code.

5. Powers and Duties:
The Code Authority, subject to such general rules and regulations as may be issued by the Administrator shall have the following powers and duties in addition to those otherwise expressly conferred under the provisions of this Code, the exercise of which shall be reported to the Administrator. Any action taken by the Code Authority shall be subject to the right of the Administrator to disapprove the same, after review and such hearing as he may prescribe, if he shall determine that such action is unfair or unjust to any member of the industry, or contrary to the public interest. Pending such hearing and after 24-hours' notice to the Code Authority the Administrator may require that such action be suspended for a reasonable period not to exceed 30 days to afford an opportunity for further investigation of the merits of such action and further consideration thereof by the Code Authority pending final action, which final action shall be taken only upon approval by the Administrator;

(a) To insure the execution of the provisions of this Code and provide for compliance by the Industry with the provisions thereof;

(b) To adopt by-laws and rules and regulations for its procedure and for the administration and enforcement of the Code.

(c) To receive complaints of violations of the Code and disputes arising thereunder. If any member of the Industry or other interested person shall request the Code Authority to take action on a matter, the Code Authority shall within ten days after such request has been received by it advise such member or other interested person of the action taken thereon. Any member or other interested person shall have the right to present any question to the Administrator for his action; provided that the Code Authority shall first have had opportunity to act thereon;

(d) To make investigation of any reported or alleged violation of the Code. When formal complaint is made to the Code Authority by any member of the industry or the Code Authority shall learn of any alleged violation, the Code Authority shall designate an impartial agency other than the Association to make such investigation as is necessary to determine the facts of the alleged violation, and to that end such agency shall be authorized to conduct such examination or audit into the pertinent data and records as may be necessary. Such agency shall report to the Code Authority its findings as to whether or not the alleged violation of the Code was actually committed. If such agency shall report that the violation did not occur, the facts ascertained in the investigation shall be confidential to the investigating agency and shall not be disclosed by it. If such agency shall report that the violation did occur and if a satisfactory adjustment thereof cannot be reached by the Code Authority, the findings of the investigating agency, together with its data and records in the case, shall be reported to the Administrator. The expense of the investigation, examination or audit shall, when made on the complaint of any member, be borne by such member if the complaint was not justified. In the event that the complaint was justified, such expense shall be borne by the member or members against whom the complaint was made.

(Note: The last two sentences above shall be effective only as to those members of the industry who shall have assented to the Code.)

(e) To obtain from members of the Indus-

try such information and reports as are required for the administration of the Code and to provide for submission by members of such information and reports as the Administrator may deem necessary for the purposes recited in Section 3(a) of the Act, which information, and reports shall be submitted by members to such administrative and/or government agencies as the Administrator may designate; provided that nothing in this Code shall relieve any member of the Industry of any existing obligations to furnish reports to any government agency. No individual reports shall be disclosed to any other member of the Industry or any other party except to such governmental agencies as may be directed by the Administrator.

(f) To obtain from the members of the Industry such other reports as may be deemed necessary to enable the Code Authority to be informed as to the observance or non-observance of the Code, and as to whether the Industry is taking proper steps to effectuate, in all respects, the declared policy of the National Industrial Recovery Act. Such reports shall be on prescribed forms covering employment and production statistics and such other information as the Code Authority may request. All data, reports and statistics from the individual

BERNARD N. ZIMMER
Vice-President, American Metal Company
Code Authority Member

members of the Industry furnished under the provisions of this subsection (f) except as otherwise provided herein, shall be confidential and shall be filed with the Secretary for compilation. The Secretary shall submit such data and statistics to the Code Authority and to members of the Industry reporting, in the form only of combined totals for the Industry unless otherwise permitted by the unanimous consent of the members reporting. If any reports received by the Secretary indicate a violation of any of the provisions of this Code by any member of the Industry, the Secretary shall report such facts to the Code Authority.

(g) To use such association or other agency as it deems proper to carry out any of its activites prescribed by the Code, provided, however, that nothing herein shall relieve the Code Authority of its duties or responsibilities under the Code and that such association or agency shall at all times be subject to and comply with the provisions hereof. Any Association and any other agency directly or indirectly participating in the selection or activities of the Code Authority shall (1) impose no inequitable restrictions on membership, and (2) submit to the Administrator true copies of its Articles of Association, By-Laws, Regulations, and any amendments when made thereto, together with such other information as to membership, organization and activities as the Administrator may deem necessary to effectuate the purposes of the Act.

(h) To make recommendations to the Administrator for the coordination of the administration of this Code with such Codes, if any, as may be related to the Industry, and to cooperate with the Code Authorities of related industries to carry out the provisions of this Code.

(i) The Code Authority may, by means of audit or otherwise, check the accuracy of all reports made by and/or to its Sales Clearing Agent and by members and provide for such audit of the same and of the books and accounts as may be deemed necessary from time to time. The report as to such examination shall not disclose the facts thereof unless it shall find that the reports which were investigated were not accurate, and in such case the report shall indicate merely the particulars in which the reports were inaccurate. Otherwise, the information obtained by the investigating agency in making the examination and audit shall be confidential.

(j) Whenever any action may be taken by the Code Authority on a question affecting only a single member of the Industry or a single group of members of the Industry, the single member or group of members whom the decision of the Code Authority shall affect may request an arbitration. Upon such request the question upon which such action was taken shall be resubmitted by the Code Authority for decision to a committee of three arbitrators, one of whom shall be selected by the Code Authority, one by the member or group of members affected, and the third shall be chosen by the first two. In the event the first two arbitrators, appointed as hereinbefore provided, cannot agree upon a third arbitrator, said arbitrator shall be selected by the Administrator. The decision of any two of three arbitrators when rendered shall be entered with the same effect as the final decision of the Code Authority.

6. Participation and Expense:
Members of the Industry shall be entitled to participate in and share the benefits of the activities of the Code Authority and to participate in the selection of the members thereof by assenting to and complying with the requirements of this Code and sustaining their reasonable share of the expenses of its administration. Such reasonable share of the expenses of administration shall be assessed against each such member of the Industry by the Code Authority on such equitable basis as may be deemed proper by the Code Authority, with the concurrence of at least one member of each of the first three groups specified in Section 1 of this Article.

ARTICLE VII

Marketing Provisions

1. Sales to Be Covered and Reported:
The provisions of this Article shall apply only to sales of duty free copper for domestic consumption except as provided in subsections (17) and (18) of Section 6 hereof. All sales of copper for domestic consumption shall be reported to the Sales Clearing Agent, and charged against sales quotas as hereinafter provided for, provided however, the tonnage of all other sales of duty free copper shall also be so reported.

2. Filing of Prices:
At least two days prior to the effective date of the establishment of any sales quota pursuant to the provisions of this Code, each party to whom such sales quota has been assigned shall file with the Sales Clearing Agent a statement showing his selling price of copper, as herein defined, together with his existing differentials. Not later than during business hours of the day preceding the effective date of the establishment of sales quota, the Sales Clearing Agent shall notify each member of his filed price and differentials, and also those of all other members, to become effective the next day. Thereafter selling prices and/or differentials may be changed by giving notice thereof to the Sales Clearing Agent prior to 2 o'clock p.m. (New York City time) on any business day except Saturday, which new price and/or differentials shall be effective at the beginning of business on the next business day. Notice to others shall be given in each case, as above provided. After notice of any such change of price and/or differential has been received by the Sales Clearing Agent, any other party having a sales quota may give like notice during the balance of that day and in such case all such new prices and/or differentials shall become effective at the beginning of business on the following business day. After the effective date of this Code no sales of copper shall be made at a price or differential other than that specified by the seller in his filed statements and in effect at the time of the sale. The Code Authority shall have the average weighted sales price computed each day and immediately furnish it to the trade papers and public press as the "Quotation issued by the Code Authority for Copper offered for sale in the Domestic Market pursuant to the provisions of the Copper Code," and the trade papers and public press shall be requested to use this quotation only for copper so offered, and to issue a separate quotation for copper not offered for sale pursuant to the provisions of this Code. The Code Authority with the approval of the Administrator, or the Administrator on his own initiative, may from time to time make such other rules and regulations with reference to filing of prices and/or differentials and the averaging and publication thereof as it may deem necessary.

3. Filing of Treatment Charges by Secondary Producers:
In addition to selling prices as filed there may, and upon request of any two producers of secondary copper there shall, be filed by producers of secondary copper a schedule of treatment charges covering the different grades of scrap material and these may be amended in the same manner as any other filed prices. Custom smelters and/or refiners shall not treat on toll any secondary copper-bearing material except:

(a) Scrap or other similar material produced by fabricators or manufacturers in the normal course of fabricating operations and tendered by such fabricators for treatment and return to them, or

(b) Scrap or such other material, the treatment of which is the subject of contracts entered into prior to March 12, 1934, or renewals thereof if approved by the Code Authority for exception.

(c) The Code Authority with the approval of the Administrator may make

ALBERT E. PETERMANN
Vice-President,
Calumet & Hecla Consolidated Copper Company
Code Authority Member

other exceptions upon request by the custom smelters and/or refiners.

By "treatment on toll" is meant treating material for a service charge payable in money or metal, and returning the copper content in refinery shapes only or its equivalent, in whole or in part.

4. Relief Against Excessive Selling Price:
If at any time during the effective period of this Code the selling price of copper shall reach a level which in the judgment of the Code Authority or the Administrator is deemed to be unreasonably high, considered both with respect to the cost of production and with respect to the consuming public, the Code Authority with the approval of the Administrator, or the Administrator on his own initiative, may temporarily suspend any or all of the marketing provisions contained in this Article VII as shall be deemed most effective in the holding of the prices to reasonable levels and in the event such action is deemed to be necessary any such stay may be made permanent.

5. Exemption From Sales Plan:
If at any time during the effective period of this Code anyone holding a sales quota thereunder shall, by virtue of the operation of the Sales Plan, have accumulated a deficit in his allocated sales in the aggregate equal to one full month's sales quota of such party, and he shall have notified the Code Authority of the existence of such deficit, and if thereafter such deficit should increase to an amount equal to the party's sales quota for one and one-third months, then upon the party giving a supplemental notice of the fact to the Code Authority, after an interval of at least ten days after said preliminary notice, all the provisions of this Article VII shall terminate, including the agreements referred to in subdivision 6, subsection 12, paragraph (c), of this Article VII.

6. Sales Plan—Quotas and Allocation:
(1) From and after the effective date of this Code all sales of copper by those governed by this Code shall be made in conformity with the provisions of this Article VII.

The Administrator upon his own initiative, or the Code Authority with the approval of the Administrator, may establish rules and regulations to effectuate the pur-

poses of the Sales Plan. Until the establishment of such rules and regulations by the Code Authority the Sales Clearing Agent shall set up rules and regulations which in his judgment are designed to carry out the spirit and intent and general purposes of the Sales Plan, subject to the review and disapproval of the Administrator. The purpose of this Sales Plan is to provide in so far as possible a first place in sales for current production and then to provide for a fair and equitable sale of stocks.

(2) Until such time as the Code Authority may determine that such member has failed to comply with the provisions of this Code and such determination has been approved for the purpose by the Administrator, the monthly sales quota for each primary producer of the industry listed below and the relative annual productive capacities of such members, arrived at solely for the purpose of establishing sales quotas, shall be as follows:

	Tons per Annum	Monthly Percentage Sales Quotas
Kennecott Copper Corporation	366,500	1.67%
Anaconda Copper Mining Company	225,000	1.67%
Phelps Dodge Corporation	168,000	1.67%
United Verde Copper Company	68,000	1.90%
Calumet & Hecla Consolidated Copper Company	50,000	2.20%
Miami Copper Company	36,000	2.30%
Magma Copper Company	25,000	2.50%
United Verde Extension Mining Company	24,000	2.50%
Consolidated Coppermines Company	21,000	2.70%
Copper Range Company	17,500	3.00%

(3) In addition to the sales quotas provided above an aggregate sales quota of 9,500 tons per month shall be allocated as individual sales quotas among the producers of secondary copper by some equitable method agreed upon by such producers and approved by the Code Authority. In the event the producers of secondary copper are unable to agree then such allocation shall be made by the Administrator.

(4) Any producer who shall assent to the Code and/or Sales Plan who is entitled to, but has not received, a sales quota may apply for a sales quota. If, however, the product of such producer is treated by a custom smelter or refiner such custom smelter or refiner may, if the producer shall fail to apply for a quota, make application in its name for the account of such producer. During the first sales period each producer of custom and by-product copper shall have a quota equal to fifty (50%) per cent of the copper produced and treated at the treatment plant. The allocation of such quota in the amount of fifty (50%) per cent of the production treated during such first sales period shall not serve as a precedent or in any way be controlling in the determination of the sales quota applied for by any such producer for the period subsequent to said first sales period.

(5) The Code Authority shall have no power to decrease sales quotas established pursuant to subsections (2) and (3), of this Section 6, save upon unanimous vote of the Code Authority and the consent of the party or parties whose quotas are to be thereby decreased. But the Code Authority upon a two-thirds vote of its membership and with the approval of the Administrator, may increase any such sales quota. In the event the sales quotas of primary producers are generally increased they shall be increased ratably to the end that the increase for each individual producer will be such as to arrive simultaneously at a sales quota equal to fifty (50%) per cent of their respective capacities; and further in the event of any increase in quotas of primary producers proportionate increases shall be made in the sales quotas of secondary producers as shall be justified by the then existing conditions.

Nothing contained herein, however, shall be construed so as to limit the right of the Administrator at any time after proper notice and giving all parties an opportunity to be heard, to make such change as he may deem necessary in the sales quotas, or Sales Plan provided for herein.

(6) Until a change is approved by the Administrator and the Code Authority, or by the Administrator alone, the aggregate sales quotas given pursuant to Subsection (2) and Subsection (4) of this Section 6 shall not exceed twenty thousand five hundred (20,500) tons per month.

(7) Allocations of sales must be accepted by those holding sales quotas provided they have copper available for delivery within the delivery period covered by such allocation, except as provided in Subsection (14) hereof. A member unable to accept a sales allocation shall have no right subsequently to make up the deficiency, except that if any producer or producers of secondary copper have been unable to accept future sales allocations beyond the current month to the same extent that such future allocations have been accepted by primary producers, then commencing with the first of the month for which such future sales allocations have been made all sales subject to allocation shall be allocated to such secondary producers to the exclusion of primary producers to the extent of the current intake of such secondary producers until such time as each of the secondary producers are brought into a proper relation with such primary producers as regards such allocated sales, provided, that this provision shall not be applied so as to give any producer of secondary copper a greater allocation of sales than if it had accepted all such future allocations.

CLINTON H. CRANE
President, St. Joseph Lead Company
Code Authority Member

(8) Sales as made shall be proportionately applied to sales quotas for the current month and at the end of the month unsold sales quotas shall be carried forward for sale and allocation during the following month, except that the unsold quotas carried forward at the end of each month for each secondary producer shall be adjusted to eliminate the tonnage by which its shortage of accumulated actual secondary intake as compared with its accumulated sales quota exceeds its sales quota for one and one-half months. If sales quotas for the current month have been sold then all sales in excess thereof shall be applied to the subsequent month for which the sales quotas have not been completely sold so that sales shall be applied to sales quotas for the current month, then to each of the two succeeding months. After the sales quotas of the current month and the next two months have been sold, further sales during the current month shall be allocated to and applied to copper stocks; provided, however, that prior to a general allocation to copper stocks there shall first be set aside fifty per cent (50%) of all sales then to be allocated to copper stocks, which fifty per cent (50%) shall be divided so that two-fifths shall go to secondary producers in proportion to their respective holdings of secondary copper accumulated since October 1, 1933, but limited in any event to such accumulations, and three-fifths to by-product and other primary stocks, and then the remaining fifty (50%) per cent (or whatever larger amount there may be available pursuant to the foregoing) shall be allocated to copper stocks generally and not to sales quotas. The Code Authority shall propose a plan for the handling of such allocations to stocks generally which shall be effective when approved by the Administrator, and which shall provide for the disposal of such accumulations by an orderly liquidation, and such sales from stocks shall be "Blue Eagle Copper" within the meaning of this Code.

(9) The sale of copper by any member of the Industry without first having received an assignment of a sales quota pursuant to the provisions of this Code, or otherwise in contravention of any of the provisions of this Code, shall be a violation of this Code; provided, however, that holders of copper who are without sales quotas and who are unable to obtain sales quotas and custom smelters and/or refineries whose intake is in excess of their sales quota and to the extent of such excess may sell such copper but it shall not be eligible to be called "Blue Eagle Copper" and shall not be considered copper offered for sale pursuant to the provisions of the Copper Code, and all invoices and papers covering such transactions shall be plainly marked "The copper covered in this transaction is *Not* Blue Eagle Copper and is *Not* qualified to be used in the manufacture of any articles for sale to the United States Government as provided for in the President's Order of Approval for the Code of Fair Competition for the Copper Industry." All sales of copper, however, shall be promptly reported to the Sales Clearing Agent of the Code Authority.

(10) It shall be a violation of this Code for any member of the Industry by any transaction with another member to buy, sell, exchange or receive any stocks of copper so as thereby to be allowed, or enable another to participate in the Sales Plan and/or receive a sales quota and dispose of copper pursuant thereto, to an extent or in such manner as would not otherwise have been possible if such purchase, sale, exchange or receipt of copper had not taken place, provided, however, that this provision shall in no manner prohibit the bona fide sale of copper produced by the seller or owned by it on the effective date of this Code, in the event that such sale is made pursuant to the other provisions of this Code.

(11) All allocations of sales quotas and stocks shall be made by the Sales Clearing Agent. A computation shall be made by the Sales Clearing Agent daily of the percentage of sales applied to each sales quota in relation to the aggregate of all quotas and a daily allocation shall be made at the average price of all sales made on that date, after making such eliminations and additions, as to sales, as may be required by virtue of the other provisions of this Code. In the event, at the end of the month, sales and purchases are necessary between those holding sales quotas in order to adjust actual sales to sales quotas, they shall be made pursuant to the daily computations and allocations made by the Sales Clearing Agent during that month. Proper allowance shall be made by the Sales Clearing Agent for differentials including freight charges, varying types and quality of copper, sales commissions, and time of delivery. Full information may be obtained upon request from the Sales Clearing Agent concerning any such computations or allocations.

POPE YEATMAN
Consulting Mining Engineer, Yeatman & Berry
Code Authority Member

(12) In order to maintain the proper relation between sales and production:

(a) Any primary producer in operation and producing copper on the effective date, or any other primary producer not producing copper on that date but which after the effective date resumes such production, which fails to produce its sales quota reasonably averaged over a period of three months, or such longer period as the Code Authority or the Administrator may have approved, shall thereafter lose its right to participate in the allocation of sales by the Sales Clearing Agent proportionately to the extent of such decrease in production; provided, however, that the foregoing provision shall not apply in the event of a shutdown or decrease in production on account of causes beyond the control of the producer or for any reason which, in the opinion of the Code Authority and the Administrator, or the Administrator on his own initiative, justifies such shutdown or decreased production; provided, further, that in addition to limitation on sales of primary copper provided in this Article VII primary producers shall limit their production so as to conform to the plan and purpose of this Code, and to coordinate the production of primary copper with current sales quotas in order to avoid excessive accumulation of stocks and any failure reasonably so to do to the satisfaction of

the Code Authority shall be a violation of this Code.

(b) No specific limitations or requirements shall be imposed upon the intake of secondary copper producers, but in lieu thereof sales of secondary copper shall be controlled and limited as provided in this Article VII. Custom smelters and/or refiners shall endeavor, so far as practicable, to limit their intake of secondary copper so as to conform to the plan and purpose of this Code, and to coordinate the flow of copper and of intake material with current sales quotas in order to avoid excessive accumulation of stocks.

(c) All consumers of copper, including fabricating or manufacturing companies owned or controlled by producers who are members of the Industry, shall be urged by the Code Authority to assist in the stabilization of the Industry by regular monthly purchases of copper in as large an amount as may be practicable in each case, and shall be similarly urged to enter into agreements to make such purchases. Upon the execution of such an agreement by a copper consumer in form and substance satisfactory to the Code Authority, or the Administrator, and for so long as the terms of such agreement are complied with, and no other copper other than Blue Eagle Copper is purchased, all copper sold and/or fabricated by such consumer shall be "Blue Eagle Copper," as defined herein. The Code Authority of this Industry shall cooperate with the Code Authority and/or Supervisory Agency of the Copper and Brass Mill Products Industry and the Wire and Cable Subdivision of the Electrical Manufacturing Industry in effectuating the purposes of the marketing and fair trade practice provisions of this Code.

(d) For the purpose of the Sales Plan, sales and/or transfers of copper by a member holding a sales quota (including any of its subsidiaries or affiliates) to its fabricating plants or to any subsidiary fabricating company, shall not be subject to said plan, except to the extent set forth in agreements made by the fabricating subsidiaries of such producer under the terms of the preceding paragraph (c); provided, however, that in case a member owning a fabricating plant or the fabricating subsidiaries of any one holding a sales quota should fail to make an agreement under the terms of the preceding paragraph (c), the sales of copper by that member shall be determined by the Administrator or, in the event of his unwillingness to act, by the Code Authority.

(e) In order to provide equitably for an increase in employment by increasing current production and/or to facilitate liquidation of excessive copper stocks in a manner which will not interfere with the operation of the Sales Plan pursuant to the provisions of this Code, the Code Authority, with the approval of the Administrator, may negotiate bulk sales of copper to, through, and/or with the approval of government agencies, provided, however, that no commitment shall be made for or become binding on any member of the Industry unless he shall accept the allocation made to him by the Code Authority of his proportionate share of any sale so negotiated, except to the extent he is obligated to sell copper under the provisions of this Code.

(13) All sales of copper made during the period from March 22, 1934, to the effective date of this Code shall be deemed for the purposes of the Code to be sales made after the effective date and shall be allocated in accordance with the Sales Plan provided for herein. All sales commitments under subsection (c) of Section 12 of this Article shall also date from March 22, 1934, and be included in the first sales period.

(14) In order to facilitate the sale of the aggregate of all sales quotas in any current month, any one having a sales quota may, prior to the first of each month, with the approval of the Code Authority, waive his sales quota or any part thereof, for the following month.

(15) In no event, however, shall any member of the Industry be required to accept allocation of sales made pursuant to the Sales Plan which will require him to reduce the amount of copper stocks held by him and unsold on March 1, 1934, less stocks liquidated by such member since that date, by more than 25% thereof, but no such limitation shall apply until the Code Authority receives notice from any such member of the Industry that further sales will require him to reduce his stocks beyond that percentage.

(16) The first sales period shall be deemed to terminate on the last day of the current month in which the effective date of the Code occurs, subject to the provisions of subsection (13) of this Section 6 and accordingly the first sales period shall extend from March 22, 1934, to the last day of the month in which such effective date occurs. The sales quota for such first sales period shall be decreased or increased as the case may be if necessary so as to bear the proper proportion to the number of days in such first sales period.

(17) In addition to other limitations which may exist pursuant to other provisions of this Code, the Code Authority with the approval of the Administrator, or the Administrator on his own initiative, may make rules and regulations governing any sales of copper in excess of sales quotas, which may limit the quantity of copper which may be sold and may also make such provisions as may be necessary

W. A. ANDERSON
Vice-President, John A. Roebling's Sons Company
Code Authority Member

to prevent excessive purchases by consumers in relation to their reasonable requirements for the immediate future; provided, however, that no provisions shall prohibit any member of the Industry from selling the full production requirements of any of its subsidiary fabricating companies.

(18) No member of the Industry shall engage in destructive price cutting.

(19) Whenever, upon complaint or on its own initiative without complaint, and after affording an opportunity to any interested party to be heard, the Code Authority is of the opinion that an emergency exists within the Industry in that destructive price cutting and/or excessive production is being engaged in to such an extent as to render ineffectual or seriously endanger the effectuation of the purposes of this Code or of the Act so as to require the establishment of minimum prices for the sale of copper and/or regulation of production, the Code Authority shall certify any such conclusion to the Administrator and, upon his approval thereof, after hearing on such notice as he may prescribe, such minimum prices and/or regulation of production may be established and the Code Authority may adopt rules and regulations satisfactory to the Administrator governing the establishment of such minimum prices for the sale of copper and/or regulation of production based on such factors and/or conditions as may be found necessary to meet such emergency; provided, however, that no provision of this Code or of any rules and regulations which may be promulgated pursuant thereto shall be interpreted so as to require any member of the Industry to reduce his production below his sales quota as originally established pursuant to the provisions of this Code. When a minimum price as herein provided for shall be established any sale below such price will be considered destructive price cutting and a violation of this Code.

ARTICLE VIII

Trade Practices

The following acts as described shall constitute unfair methods of competition by members of the Industry in respect of copper sold and/or delivered for consumption in the United States:

1. The sales or exchange of copper in refinery shapes at premiums or discounts other than those established and recognized in the trade, and in accordance with statements filed with the Code Authority;

2. The sale, transfer, or exchange of copper in a manner planned and effective to impair or defeat the purposes of this Code;

3. The alloying of copper in any manner for the purpose of evading the provisions of this Code;

4. A failure within 30 calendar days after receipt at plant to price custom copper, by-product and secondary copper material. Copper-bearing material received at plant prior to the effective date of this Code shall be exempt from this provision;

5. The sales of copper to persons other than consumers of copper and dealers, provided, however, that there shall be no prohibition against exchanges of copper customarily heretofore made between producers and/or custom smelters;

6. Sales of copper made for delivery further ahead than the three months following the month of sale.

This Code and the provisions thereof shall be the standard of fair competition for the Copper Industry in the United States, and every violation of the standard established in the Code shall be deemed an unfair method of competition and shall subject the party guilty of any such violation to penalties as provided in Title I of the Act.

In order to facilitate the enforcement of the Executive Order of the President No. 6246, dated August 10, 1933, and the Executive Order of the President No. 6646, dated March 14, 1934, concerning Government Contracts for supplies, and to effectuate the purpose of the Act and this Code, it is provided that:

(a) Only copper sold pursuant to the marketing provisions of this Code shall be entitled to be called "Blue Eagle Copper" and only "Blue Eagle Copper" shall qualify as complying with the Executive Orders above referred to. Certificates for the purpose of complying with said Executive Orders of the President shall provide that all articles covered by such certificates shall be completely free of any copper save "Blue Eagle Copper."

(b) For no other purpose of this Code shall copper be deemed to be such copper as has been sold pursuant to the provisions of this Code if the same shall contain any copper other than "Blue Eagle Copper."

(c) The Code Authority, or the Administrator, shall provide rules and regulations for determining the eligibility of copper to be called "Blue Eagle Copper."

(d) All "Blue Eagle Copper" shall either be stamped with the replica of the N.R.A. insignia when such copper passes through the smelter and/or refinery, or be accompanied by a certificate by such smelter, refiner, and/or Code Authority that such copper is "Blue Eagle Copper."

ARTICLE IX

Applicability of Code to Various Operations

1. If any member of the Industry is also a member of any other industry, provisions of this Code shall apply only to that portion of its business which is a part of the Copper Industry.

2. Where there is any question as to whether copper is the major production from the operations which do or which might produce lead, zinc, gold, silver or other materials, then in any and every such event the question as to which Code of Fair Competition shall govern such plant or mine operations of any such member of this industry shall be referred to a Coordination Committee. This Coordination Committee shall be composed of two members to be appointed by each of the Code Authorities for such industries as may be involved in each particular question. In the event such Committee is unable to reach a majority conclusion, then either the Committee shall elect an additional impartial member or upon their failure so to agree on such additional impartial member, the Administrator then may appoint such additional impartial member. Any member of the Industry, the operations of which may raise such a question, shall file a statement of fact with the Code Authority for its industry, and such statement shall contain a statement of its preference as to the Code it would prefer to have such operations be governed by, and such preference shall be granted unless such Coordination Committee shall find that the granting thereof would be unfair in view of the rights of others or that it would have a tendency contrary to the effectuation of the policies of the Act. Any action taken by the Coordinating Commit-

tee under any of the provisions of this Article IX shall be subject to the approval of the Administrator.

3. Within ten days after the effective date of this Code any member of this Industry may file such statement of fact and preference as to being governed by any of such other Codes which may at that time be in effect. Thereafter upon any such other Code becoming effective such statement may then be filed; provided, however, that until any such statement is filed and decision is made thereon by such Coordination Committee, such operation of such member of this Industry shall be governed by the provisions of this Code.

4. From time to time thereafter if conditions change members of this Industry shall be entitled to file such statements of fact and preference as to change of portion of their operations from the jurisdiction of one Code to the jurisdiction of another, and in such event they shall be handled in the same manner as provided for above.

5. The foregoing Sections 1 to 4 inclusive of this Article IX, shall not be effective until Codes of Fair Competition for the lead and zinc industries, containing an article substantially the same as this Article IX, have been approved and are in effect and certified copies of such approved codes have been filed with the Code Authority for this Industry.

ARTICLE X

Modifications:

1. This Code and all the provisions thereof are expressly made subject to the right of the President, in accordance with the provisions of subsection (b) of Section 10 of the Act, from time to time to cancel or modify any order, approval, license, rule, or regulation issued under Title I of said Act.

2. The provisions of Articles I to VI, inclusive, and Articles VIII and IX of this Code, excepting those required to be included therein by the Act, may be amended as provided in Section 3 hereof in such manner as may be indicated by the needs of the public, by changes in circumstances, or by experience; but no amendment may be made under the provisions of Sections 2 and 3 of this Article X in respect of the subject matter of Article VII.

3. Any such amendment referred to in Section 2 hereof may be proposed by any member of the Industry either to the Code Authority or to the Administrator. Any such proposed amendment shall be referred to the Code Authority who shall give members of the Industry an opportunity to be heard thereon. After any such amendment has been recommended by the Code Authority and upon approval by the Administrator, after such hearings as he may deem necessary, it shall become effective as a part of this Code.

ARTICLE XI

Monopolies:

No provision of this Code shall be so applied as to permit monopolies or monopolistic practices, or to eliminate, oppress, or discriminate against small enterprises.

ARTICLE XII

Effective Date, Term and Termination of Code:

This Code shall become effective on the 5th calendar day after its approval by the President.

The term of this Code shall be from the effective date to June 16, 1935, subject to the provisions hereof and of the National Industrial Recovery Act, as effective June 16, 1933.

(Signed) HUGH S. JOHNSON,
Administrator for Industrial Recovery.

Approval Recommended:
(Signed) K. M. Simpson
Division Administrator
Washington, D. C.
April 21, 1934.

Plant Increases and Development Feature Mining Activity

SUBSTANTIAL additions to existing plant and the undertaking of extensive development programs were outstanding features of operations in the various mining districts last month. Arizona-Comstock (Nevada), for instance, was completing a cyanide leaching plant and enlarging its flotation plant; Idaho Maryland (California) started its new cyanide plant, and this month will finish construction of a new flotation plant; American Smelting & Refining, at the Utah Metal & Tunnel lease (Utah), and International Smelting, at the Mountain City Copper property (Nevada), are both proceeding steadily with shaft sinking and development. Phelps Dodge announced the early resumption of operations at its New Cornelia mine (Arizona), and Eagle-Picher Lead reopened its Montana Mines property (Arizona). An enterprising board of county commissioners (Keweenaw County, Mich.) leased an abandoned copper property and will convert it into a "dress-suit" mine for tourist-enticing purposes.

Reports of the major developments in the various mining districts of the country during the last month are presented in the following paragraphs.

Nevada

At the Tybo lead-zinc mine of Treadwell Yukon, the 300-ton flotation mill is running on ore that had been broken in shrinkage stopes. A full mine force is employed in development and stoping, and a contract has been awarded a California trucking company to deliver concentrate to the railroad at Tonopah, 65 miles distant.

Gold Circle Consolidated, at Midas, Elko County, owning several adjoining mines, has unwatered the south workings of the Elko Prince mine to the bottom, or 900-ft. level. An ore pocket is being completed at this level, and N. H. Getchell, manager, is preparing to mill 75 tons per day in the cyanide mill, supplementing mill feed from another property at the north. In the same district several lessees are working in ore of high grade. East Standard, a Utah company, has installed a Lane mill with amalgamating plates and South African corduroy tables. Miners Gold has been shipping gold ore to a Utah smelter. George Crosby is developing the St. Anthony group. New York and California interests are working, respectively, the Alta and Esmeralda mines.

Ore from the outcrop of the Comstock lode, on the Hale & Norcross mine, one of the so-called middle group of early bonanzas, will be mined by the open-cut method by Arizona-Comstock, and will supplement the product of stopes in the Savage, Hale & Norcross, Chollar, and Potosi mines. W. J. Loring, president and directing engineer, says that more than 400 samples from the wide outcrop indicate a large area of pay ore. Quarried from the steep slope of Mount Davidson, the ore will be loaded into trucks by power shovel and transported about 1,000 ft. over a double-track bridge to a newly constructed 425-ton crusher bin. The flotation mill, treating heretofore 130 tons per day, is being enlarged to 300 tons' capacity by adding an 8-ft. x 36-in. Hardinge ball mill, a second 8-cell Denver flotation machine, a second Dorr duplex classifier, and a larger Oliver filter. A larger gyratory crusher also has been installed, following a primary jaw crusher. Tests are being made with a new Denver Sub-A flotation cell. Several hundred feet below the flotation mill a 300-ton cyanide leaching plant is being completed to treat tailing from the flotation mill, the company having bought two Oliver filters, eight thickeners, five agitators, diaphragm pumps, and Merrill-Crowe precipitation equipment that was used in the Rochester Silver mill. Lou M. Lewis is directing construction.

Noteworthy results of exploration on the 1,100-ft. level of the Overman shaft, below Gold Hill, and between the south projection of the Comstock lode and the Silver City branch to the southeast, are reported by R. J. Duncan, manager. After making connection with the 1,200 level of the New York shaft and obtaining necessary ventilation, a crosscut was driven on the 1,100 to the Silver City vein, entering old stopes, where additional work is said to have exposed a 32-ft. width of high-grade ore. The 60-ton flotation mill is being enlarged by the addition of an 8-ft. x 22-in. Hardinge ball mill, duplex classifier, a second 6-cell Kraut flotation unit and larger crusher. Equipment also includes two Deister Plat-O concentrating tables. A working force of 65 men is employed in the mine and mill.

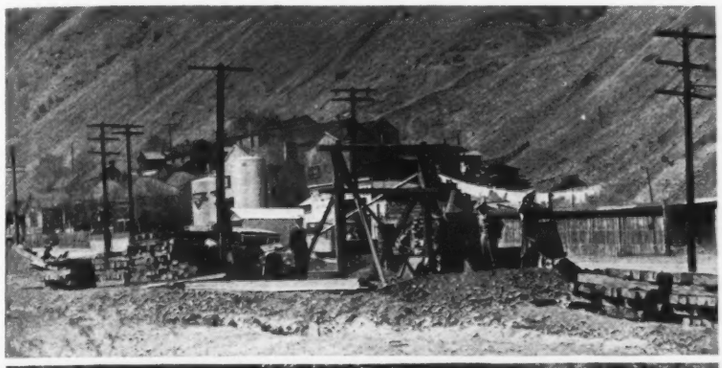
Dayton Consolidated, having acquired the old Dayton mine, in Gold Canyon, below Silver City, has completed construction of a 150-ton cyanide mill, and the management reports the blocking out of a substantial tonnage of mill ore. Equipment was taken in large part from the Flowery Mines mill, in Sixmile Canyon. The Dayton mine was closed down in 1877 and, late in 1932, was reopened and unwatered to the 200-ft. level by George Fuerman, of Virginia City, who had secured a lease and option from the Hobart estate, of San Francisco. The option was sold last year to Homer L. Gibson, C. M. Wil-

lock, and A. B. Slack, of Pasadena; John C. Higgins, of New York; and C. N. Miller, of San Francisco, who completed payment and perfected title last October.

Bradshaw, Inc., treating tailing from the dismantled 1,000-ton mill of Goldfield Consolidated, has enlarged capacity of its leaching plant from 1,000 to 1,500 tons per day. Completing last year the equipment includes storage-battery mine locomotives, electric mucker, drill sharpener, and a "jumbo" designed by E. S. McCurdy, directing engineer, and constructed of steel I-beams. Machine drills are mounted on arms attached by universal joints to 3-in. columns of steel pipe at the front of the truck, which runs on ball bearings, with wheel clamps to hold it in position. Stone

Placer Mining Returns to Damphool Gulch, Bingham Canyon, Utah

Before Bingham became a famous copper camp, the area was mined by placer methods for the recovery of gold. United States Army troops under General Patrick E. Connor are reported to have panned gold there in pioneers days



Above—One of several shafts now being sunk in the gravels by leasers. Below—A sluicing operation along the main channel of the gravels, where Bingham Creek Gold Placer Mines has acquired the West Mountain and Clays claims

treatment of the tailing of best grade, a final clean-up was made with the purpose of abandoning the project, but the new price for gold rendered profitable the treatment of material that contained only 85c. per ton, under the old price. An option to purchase the Ramsey Comstock mine, in the Flowery range, 35 miles east of Reno, has been surrendered by Rainier Investment & Mining.

Two mines in the Como district, 15 miles east of the Comstock lode, are being developed on a substantial scale. Como Mines, owning the Como and Rapidan mines, is driving two long laterals, breasting 8x8 ft., to cut the Como and Rapidan veins at a depth of about 650 ft. Shaft workings have developed large bodies of ore in both veins to a depth of 350 ft. Complete Cabin Consolidated, with three adjoining mines 4 miles north of the Como camp, also is developing through a tunnel, and has completed grading for a 200-ton flotation mill, much of the equipment having been obtained from the Hilltop mine, in Lander County.

Preparations are being made at the Prince Consolidated mine, in the Pioche district, to resume production after several years of inactivity. Repairing of the broad-gage railroad between the mine and Pioche has been started. Activity will be limited to the development and shipment of direct smelting ore.

For some time the management—David B. Gemmell & Sons—has been concentrating on development of the third level, east of the shaft, to undercut a bedded deposit.

Operation of the East Standard Mining's milling plant at Midas is proceeding satisfactorily, according to Harry S. Joseph, the manager. Fifty tons a day is being treated. A 5-ft. vein, exposed in the Devine tunnel, has added considerably to ore reserves, Mr. Joseph reports.

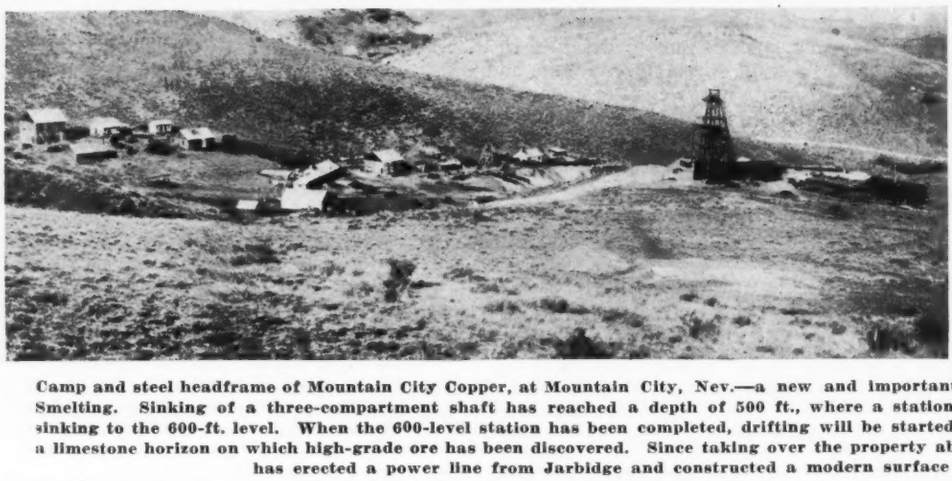
Arizona

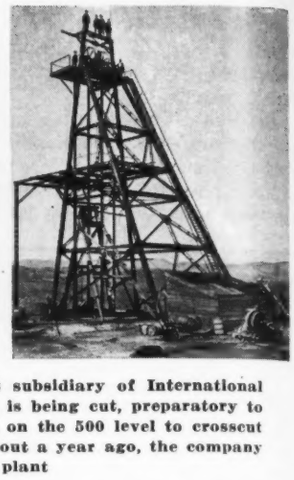
An important event for the Arizona copper-mining industry will be the reopening of the New Cornelia mine of Phelps Dodge at Ajo. P. G. Beckett, vice-president and general manager of the corporation, has announced that mining operations at that plant will be resumed on a moderate scale in July. The decision to resume operation was made in anticipation of increased export sales of copper. Besides restoring employment at Ajo, shipment of concentrate to Douglas will increase the tonnage to be smelted there and will lead to an increase in the number of men on the smelter payroll.

Two cars of ore containing gold are being shipped weekly to the smelter at Douglas from the Max Delta mine, in the foothills of South Mountain, 10 miles south of Phoenix. The property has been leased on bond from the owner, T. C. McReynolds, Jr., by a group of eight men who have incorporated as Ace Mining & Development. The president is Claude E. McClain. W. M. Snow is secretary-treasurer and mine superintendent. The Ace company has discovered an important new vein, but several of the stopes are in veins found by previous operators. At present work is being carried on in three tunnels from which the ore is trammed by hand to an ore bin on the truck road; in an open cut which is not reached by the road and from which the rock must be packed by burros; and in the 100-ft. Hall shaft, which is in the valley below the tunnels. At this shaft a wood headframe has been erected and an Albert Steinfeld single-drum hoist, geared to an 8-hp. Sears & Roebuck gas engine. Skip pockets are being cut in the shaft at the 50-ft. level in preparation for stoping along the 3½-ft. vein which intersects the shaft at this point, and one of the portable compressors is being used for this work.

More than 200 men are employed in mining and milling operations in the Oatman district at present. The Tom Reed mill is treating from 110 to 140 tons daily of its own ores, leasers' ores, and shipments from other properties. The Telluride mill is treating from 50 to 60 tons of ore daily, mostly from the Big Jim. Golden Belt Mines, at Cordes, of which A. L. Lampton is manager, shipped concentrate valued at $22,000 during January of this year.

Montana Mines, at Ruby, owned by Eagle-Picher Lead, is resuming operations with an initial crew of from 30 to 40 men under the supervision of Grover J. Duff, formerly assistant





Camp and steel headframe of Mountain City Copper, at Mountain City, Nev.—a new and important subsidiary of International Smelting. Sinking of a three-compartment shaft has reached a depth of 500 ft., where a station is being cut, preparatory to sinking to the 600-ft. level. When the 600-level station has been completed, drifting will be started on the 500 level to crosscut a limestone horizon on which high-grade ore has been discovered. Since taking over the property about a year ago, the company has erected a power line from Jarbidge and constructed a modern surface plant

superintendent of the North Lily mine, at Eureka, Utah. The Montana is a lead-silver-zinc mine, equipped with a 300-ton concentrator.

California

Idaho Maryland Mines has placed its new cyanide plant in operation on concentrates from the Brunswick and Idaho Maryland mills. Concentrates were formerly shipped to the Selby smelter for refining. Work on the new flotation plant is proceeding satisfactorily, and the plant is scheduled to be in service this month.

Standard Eureka Gold Mining is driving a 1,500-ft. tunnel on its holdings at Greenville, to open orebodies 750 ft. below the old workings. Plans of the management also include erection of a larger mill. Equipment now on the property includes a 50-ton mill.

Anglo-American Mining is reported to have taken an option on the Imperial property near Newberry, San Bernardino County, one of the largest silver-lead properties in the Barstow territory. The company also operates the Yellow Aster mine, at Randsburg.

Erection of a 45-ft. steel headframe and shops at the Keystone mine, Amador City, has been completed by the Snyder interests, of Salt Lake City, and unwatering of the Keystone and South Spring Hill shafts is to start at once. Levels in the Keystone are to be extended into the South Spring Hill mine.

Twenty-five men are employed at the Omega gravel mine, north of Washington, where hydraulic and sluicing operations are in progress. The property is controlled by the Hoge interests, of Nevada City.

The Alta Hill mine, northwest of Grass Valley, is being rehabilitated by the Cooley Butler interests, owners of the Golden Center and Black Bear mines, in the Grass Valley district. Preparations are under way to unwater the shaft and recondition surface structures.

Argonaut Mining, operating the Argonaut mine, at Jackson, reports the discovery of a new vein on the 5,700-ft. level. Drifting has been started on the 5,400-ft. level to define the height and extent of the orebody. The mill is treating more than 250 tons of ore a day.

Beebe Gold Mining, a Bradley subsidiary, operating the Beebe, Eureka-Woodside, and Alpine mines, at Georgetown, has increased its daily production from 200 to 400 tons by putting into service the second Hadsel unit at the mill. The mill is receiving more than 300 tons from the Beebe mine and the remainder from the Alpine mine.

Michigan

Calumet & Hecla is developing a profitable market for copper oxide, selling nearly 2,000,000 lb. last year at 6.09c. a pound. The cost was 5.23c. The oxide is used in the chemical industry for various purposes. All commercial rock in No. 9 South Hecla shaft has been removed and the men have been transferred to No. 7 Hecla shaft. Output of the latter unit has been increased to offset the loss entailed by abandoning No. 9 South Hecla. Six shafts are in operation, mining being confined to the old backs and shaft pillars in the upper part of the rich Conglomerate lode. Calumet & Hecla is using only electric hoists in its present mining operations, four of these plants being in commission. They are giving satisfactory results, the cost of hoisting having been greatly reduced. Another saving has been made through the use of four electrically operated air compressors. They are furnishing all the compressed air that is used at a much reduced cost.

The board of supervisors of Keweenaw County has taken a long-term lease on the old Ashbed mine and will convert it into what promises to be one of the most unusual tourist attractions in the upper peninsula of Michigan. The mine will be put in repair and equipped so that visitors may go underground and view the interior of a copper property. Many tourists coming into the district express a desire to go down into a mine. The Ashbed mine is reached through a 780-ft. tunnel, from which one may visit the stopes and drifts and return to surface through a shaft. The mine is along Highway M-129.

Utah

The new triple-compartment shaft of American Smelting & Refining, being sunk in the company's Utah Metal & Tunnel lease, is rapidly nearing the 1,200 level below the Armstrong tunnel level. The company plans to sink to the 2,000 level before drifting.

Shafts in the Apex Standard property of Chief Consolidated Mining are being put in condition to sink to the horizon from which, in the adjoining Eureka Standard mine, gold shipments are being made.

Two shifts, comprising seventeen men in all, have been put to work by the Park City Utah Mines, in the Star of Utah tunnel of New Park Mines. Work has been started near the side lines of Park City Utah Mines and New Park Mines, where a crosscut is being advanced in a northerly direction. Later, raising will be done to reach the Weber quartzite, estimated to be about 200 ft. above the level. In the New Park Mines property, a crew of men is at work in the Mayflower tunnel. A recent change in the formation gives promise of the tunnel encountering the downward extension of the rich ore opened up in the old Park Bingham property.

To expedite development of the Crescent fissure, a new electrically driven hoist has been installed by Park City Consolidated Mining. The winze is being sunk to develop the sulphide zone, productive in the Silver and Roosevelt fissures, from which major production is coming.

An excellent showing of gold ore has been opened up on the 1,100 level of the American Flag property, a short dis-

tance from the main property, reports A. L. Hurley, manager of Park City Development. This fissure parallels the American Flag vein, which has been productive on virtually every level in the property down to the 1,100 level. The American Flag property lies in the quartzite, between the Silver King Coalition and the Park Utah Consolidated properties.

A portable Chicago Pneumatic five-drill compressor has been installed at the property of Sheba Gold Mines, on the Goshute Indian reservation in the Spring Creek mining district in the Deep Creek range, 28 miles south of Gold Hill. The company has also completed a 1,000-ft. jigback, to transport ore from the tunnel to the mill and replace team haulage. About 1,400 ft. of 10-in. spiral pipe is also being installed to convey 2½ second-feet of water to a Pelton wheel, which will develop 120 hp. of electricity, according to estimates. Two shifts are being worked. The orebody, which lies at intersections of the granite-quartzite contact and an east-west system of fissures, is supplying ore that carries a fair amount of gold.

Montana

Basin Montana Tunnel, at its recent annual meeting of stockholders, ratified plans for the construction of a mill at the company's Comet mine, northeast of Basin. A crew of 50 men is now working at the Comet and Grey Eagle mines, and ten men are breaking ground for the mill, which is expected to be finished and operating in less than four months. The flowsheet and the plant were designed by George G. Griswold, Jr., metallurgist of Butte; Hugh Carmichael will be in charge of construction, under supervision of Walter Phelps Jacob, managing director, and Leo F. Coady, manager.

Under lease to Yuba Associated Engineers, Gold Creek Mining is operating its floating dredge near the town of Pioneer, Powell County. The dredge is said to be handling about 7,000 cu.yd. of gravel per day. Costs are said to be below 10c. per cubic yard. Newton Cleaveland, of California, is in charge of operations.

Comstock-Gold Point Mining, according to reports from San Francisco, has acquired a half interest in the Jib group, at Basin, which is being operated by Roy Miller, Inc.

Montana Chrome has started mining chrome and conducting metallurgical tests on a small scale at the Hellroaring chrome deposits, near Red Lodge. The deposits are situated in Stillwater County and are said to be the largest in the United States. E. B. Hubbard, of Livingston, is in charge of operations.

Vosburg Mining is installing new mining machinery, camp buildings, and equipment at its property near Winston, Broadwater County, according to Clinton M. Roos, organizer of the company. Fifteen men are on the payroll, and a car of gold ore was shipped recently. The company also is working the Stray Horse group, near Townsend, in the same county. John Roos is in charge of operations, which are being financed by the Associated Gold Mines, of Seattle.

Basin Goldfields has repaired its road to Basin and is hauling high-grade gold ore for shipment to the Washoe smelter, according to A. P. Peake, president.

Minnesota

As soon as navigation opened, early this month, ore was waiting in the docks for the boats, as ore car loading started on April 2 at the Evergreen and Croft mines, on the Cuyuna range. At present most of the underground mines on the Mesabi and Vermillion ranges are loading cars from the shaft, and the railroads are busy getting all ore cars in condition for a busy season.

Much gratification was manifested throughout the ranges when the operators announced a 10 per cent increase in wages, dating from April 1 and coinciding with the wage increase announced for the whole steel industry. Employment at the mines is picking up, and expectations still are that 40,000,000 tons will be shipped this season. The trend of the times was observed at the Mesabi Chief mine of the M. A. Hanna Company, where a new 120-B Bucyrus electric shovel was received recently, the first new shovel of that capacity that has been purchased on the range for several years.

Idaho

At the Page mine, west of Kellogg, Federal Mining & Smelting has just proved the continuation of the main oreshoot to the 1,500 level, where it is larger and of better grade than on the levels above. This development has enlarged the outlook for future production, conditions indicating increased length of the oreshoot on the 1,500 level and its persistency at depth.

The shaft at the Sunshine mine has reached the 2,300 level, and preparations are being made to crosscut to the vein. On the 1,900 level, the present deepest productive level, the vein is larger and runs higher in silver than on the level above. Expectations are that on the 2,300 level, 400 ft. below the 1,900, the oreshoot will at least maintain its size and high silver content.

Extension of the shaft at the Morning mine an additional 200 ft., from the 3,650 to the 3,850 level, is practically completed, and crosscutting to the vein will soon be under way. Likewise at the Hecla mine, sinking the shaft an additional 400 ft., down to the 3,200 level, has been completed.

An important lead-silver strike is reported to have been made by Atlas Mining, operating near Mullan.

President Announces Appointment Mineral Planning Committee

CARRYING out his policy of attempting to keep production in step with demand, and to guard the public against investment in excess capacity, President Roosevelt has announced the appointment of a "Planning Committee for Mineral Policy," with Secretary Ickes acting as chairman.

The committee is to study such fundamental problems as future consumption of important minerals; curtailment of production; relationships of federal and state control, and the coordination of emergency appropriations which have a bearing on the mining industry.

Under codes, much reorganization of the mining industries is expected. The President is greatly interested in conservation and in preventing ruinous expansion. He realizes that what has happened in coal can happen in other mineral industries.

In recent years, coal operators have seen the closing of half their mines, only to find that the remaining half could furnish more coal than the market could absorb. Despite this fact, 5,000 new mines have been opened during the past year. The instability in the industry and the human suffering that goes with it are conditions which the Administration is trying to correct.

Before much can be done in the way of planning, there must be some forecast of probable demand during the next twelve months. This will be the first task the committee will undertake.

The members of the committee follow:

Harold L. Ickes, Secretary of the Interior, chairman; Dr. C. K. Leith, University of Wisconsin, Madison; Herbert Feis, economic adviser, State Department; James W. Furness, chief, Minerals Division, U. S. Bureau of Foreign and Domestic Commerce; Walter C. Mendenhall, director, U. S. Geological Survey; Wayne C. Taylor, Washington; Lieutenant Colonel Emmet R. Harris, War Department; Scott Turner, director, U. S. Bureau of Mines; Ferdinand A. Silcox, chief, U. S. Forestry Service; Willard L. Thorpe, director, U. S. Bureau of Foreign and Domestic Commerce; Leon Henderson, director, NRA Research and Planning Division.

Canadian Tax on Gold Production Raises Storm of Protest

Quebec, Ontario, Manitoba, and British Columbia Operations All Include Much Exploration Endeavor—Ore Reserves at Dome's "New Mine" Large—Flin Flon Plans to Suspend Open-Pit Mining

STRONG protest against a proposed 10 per cent tax on gold output of the mines, which proposal was put before Parliament in the budget of the government at Ottawa the latter part of April, led to the government substituting on May 2 a 25 per cent tax on profit derived from the difference between the present gold price of $35 an ounce and the statutory figure of $20.67, according to a news dispatch of that date appearing in the *New York Times*.

Low-grade mines will not be subject to the tax unless and until they become dividend payers. No companies which did not earn dividends before Jan. 1, 1933, will pay the tax this year. The tax, which will cease if the price of gold drops below $30, will cost high-grade producers $3.58 on each ounce of gold produced as compared with $3.50 under the 10 per cent tax. Defending the principle of the tax, Premier Bennett stated that "the present premium on gold was unearned income arising out of the action of the United States Government."

Despite the heated comment that gold-taxation proposals have occasioned recently in the Dominion, a more balanced view is said to prevail generally among the mining fraternity. This opinion was voiced appropriately by S. G. Blaylock, president of the Canadian Institute of Mining and Metallurgy and vice-president and general manager of Consolidated Mining & Smelting, at a meeting of the Montreal branch of the Institute on April 26. Mr. Blaylock stated his belief that the mining industry would be called upon to provide an increasing part of the country's revenue to meet external obligations — a development that is already well under way, as evidenced clearly by the diminishing exports of wheat and the increasing exports of metals. He pointed out that the metals of Canada are produced, in general, at a lower cost than elsewhere in the world, which assures them of a market.

Similarly, the mines will have to bear an increasing proportion of the load of debt within the Dominion, which is reasonable and just in view of the increasing proportion of the country's total income provided by the products of the mines. Just how this increasing proportion of the taxes is to be distributed cannot be determined offhand; but the logic of the situation is inescapable.

A novel and interesting view prevails among the miners and staffs who are actually producing the gold in the north country. Many of them have noticed the fact that their salaries and wages have not been increased one dollar in response to the enhanced price of gold —in fact salaries and wages have been reduced at several of the large mines. Where is this extra money going?, they ask. If it is going only to the shareholders, who are not dividing the gains with the men who are working the mines and making all this new wealth available, the government should take a part of the increase by way of taxes, they say. This view certainly has some merit, and it is worth serious consideration.

Ontario

Dome, whose obituary has been written several times during its 25-year career, had in 1933 one of the best years in its history. The mill is extracting more than 98 per cent of the gold in the ore. The value of the "new mine" at and below the 23d level at some distance to the east has not yet been definitely proved, but is distinctly interesting. On the 23d, 24th, and 25th levels about 250,000 tons of ore has been partly developed. The 26th and 27th levels in this area are being opened.

At Lake Timagami, a highly mineralized area, but one long discredited, includes two active properties of considerable promise. One, Bobjo Mines, has installed a diesel-driven power plant to permit of a rapid development on two levels of an unusually promising gold deposit, indicated on the surface and by drilling. Two miles away, the other, Cuniptau Mines, is opening a wide mineralized zone on the 100-ft. level that contains the metals whose symbols form the first word in the company's name—copper, nickel, platinum, and gold. Surface showings indicate a somewhat erratic occurrence of these metals, but the consistency of pyrite and pyrrhotite in the mineralized zone gives rise to the hope that payable concentrations of ore will be found.

Halcrow-Swayze will be the first producer in the Swayze gold field, northwest of Sudbury. A diesel-driven 25-ton test mill is in the course of erection on the property. Values are erratic, and the management has decided that bulk-sampling by milling is the only satisfactory way of determining the average values. Drifting on two levels has shown rather restricted occurrences of ore of good grade, and the management hopes that a large tonnage of low-grade material of payable grade will be proved. Diamond drilling from the 200-ft. level is under way to intersect the vein system at 500 ft.

At Tashota, just east of Lake Nipigon, where a number of small lenses of ore of good grade were outlined some years ago, a 35-ton mill operated by a diesel engine has been installed by Tashota Goldfields. A vigorous search for additional ore will be conducted, concurrent with the milling of the known ore, amounting to about 15,000 tons.

A substantial activity prevails in the 300-mile stretch from the Central Manitoba field eastward through Red Lake to Crow Lake. At Gunnar Gold, in the Manitoba field, mine development to 500 ft. is under way, following favorable results from diamond drilling. At Red Lake surface work and drilling are going on at a number of prospects. MacKenzie Red Lake, in which Mining Corporation has acquired a controlling share interest, has shown a substantial amount of ore on the 250-ft. level, under the energetic management of John W. Shaw. The 50-ton mill of Central Patricia, the operation of which has been delayed for a year through the loss in transport over the ice of certain essential parts, has now started to work on its 45,000 tons of high-grade ore. Pickle Crow Gold Mines, with a smaller amount of ore of similar grade in sight, is sinking to 625 ft. The two last-named properties will be served within a year by electrical power from a plant being installed near by on the Albany River by the Hydro Electric Power Commission of Ontario.

British Refiners Doubles Plant

British Copper Refiners has found necessary the doubling of the capacity of the plant erected in England three years ago to fire-refine Roan Antelope copper.

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World Production of Gold

(American Bureau of Metal Statistics)

In Fine Ounces

	Jan.	Feb.	March
United States (a)	235,000	176,000	227,000
Canada	231,000	223,000	237,000
Mexico	52,000	55,000	(f) 55,000
Colombia	33,000	(f) 27,000	(f) 30,000
Other South America	52,000	50,000	53,000
British India (e)	27,000	25,000	26,000
Japan (e)	35,000	(f) 35,000	(f) 35,000
Queensland	7,000	6,000	(f) 7,000
Western Australia	55,000	52,000	(f) 55,000
Other Australasia (b)	36,000	34,000	37,000
South Africa	914,000	826,000	874,000
Belgian Congo	20,000	20,000	22,000
Rhodesia	58,000	54,000	57,000
British West Africa	30,000	30,000	32,000
Russia (c)	(f) 200,000	(f) 200,000	(f) 200,000
Elsewhere (d)	(f) 110,000	(f) 106,000	(f) 110,000
Totals	2,095,000	1,919,000	2,057,000

(a) Includes Philippines. (b) Includes New Zealand and New Guinea. (c) Chiefly Siberia. (d) Includes West Indies, Central America, Europe, and Asiatic and African lands not separately reported; estimated. (e) Principal mines, nearly complete. (f) Conjectural.

Dredge No. 4—"Delta" of the "Alpha-Beta-Gamma-Delta" fleet—which Bulolo Gold Dredging has under construction at Bulolo, New Guinea. This dredge, similarly to dredge No. 3 ("Gamma"), will be equipped with jigs and flotation machines

British Columbia

In the Bridge River district, preparations for active mining operations on the Bradian Company's properties are under way, ample capital having been provided for that purpose by Bralorne shareholders under their option to acquire an interest in this undertaking. Already, the necessary buildings have been erected, a power line has been installed, and the old workings have been put into condition. At the Bralorne, mine ore reserves are being increased rapidly, and in April the mill was stepped up to treat 250 tons per day. Milling capacity may be increased to 400 tons before the close of the present year. At the Wayside, erection of a 300-ton mill, having an initial capacity of 100 tons, is in progress.

Some rich ore is being mined from the 5th level of the Pioneer mine, and satisfactory results are also attending developments at depth, where new and rich oreshoots have been discovered. Arrangements are proceeding to sink a further 750 ft. below the present 1,400-ft. level, or to a total depth of 2,400 ft. By improvements in practice and without any considerable capital expenditure, the milling capacity is being steadily increased and is at present being maintained at the rate of 360 tons a day.

At the Bralorne no less satisfactory results are being achieved. The mine manager has recommended that another unit be added to the mill, whereby its capacity will be increased to 400 tons daily. Production of the company last year amounted to 25,935 oz. This will probably be at least trebled during the current year.

The development now taking place on such properties as the BRX, Minto, Congress, Wayside, and others indicates the occurrence of bodies of low-grade ore which may become the basis of large tonnage operations.

Proserpine Gold Mines has been incorporated to acquire and operate a group of properties on Proserpine Mountain, in the Cariboo district, on which for the past year development has been carried on under the auspices of R. R. Wilson and associates. The work has been directed by C. M. Campbell, formerly resident manager for the Granby company at Phoenix.

In the Kamloops area, the new mill at the Windpass is in regular operation, and at the Vidette a 40-ton mill went into commission last month. In the Boundary district, developments at the Dentonia are proving exceptionally satisfactory, and the recently completed mill, having a capacity of 100 tons a day, is in operation.

The old gold mines in the Fairview district which are being reopened are responding in a promising way to exploration, and at least one or two considerable operations, based on a large tonnage of low-grade ore, will probably be developed. At the Morning Star, the shaft is in ore to a depth of 400 ft., and drifting is to be undertaken. Meanwhile, the extension of No. 2 level has disclosed that the high-grade ore encountered on the level above expands downward to this horizon. Attention has also been directed to the opening of old properties in the Camp McKinney area. During April, Morning Star Gold Mines acquired the old Stemwinder mine from a subsidiary of American Smelting & Refining. At the Columario, at Usk, the management has decided to erect a 100-ton mill, instead of one of 50 tons, as originally planned.

World Production of Silver

(*American Bureau of Metal Statistics*)

In Fine Ounces

	Jan.	Feb.	March
United States	2,025,000	1,903,000	2,791,000
Canada	1,368,000	1,351,000	1,085,000
Mexico	6,255,000	5,413,000	†6,000,000
Peru	618,000	548,000	548,000
Other America	850,000	815,000	860,000
Europe	1,200,000	1,000,000	1,300,000
Australia, refined	844,000	790,000	799,000
Other Australia and New Zealand	227,000	238,000	†240,000
Burma, refined	486,000	489,000	490,000
Other Asia	700,000	700,000	725,000
South Africa	87,000	†85,000	†87,000
Other Africa	40,000	36,000	†40,000
Total	14,700,000	13,368,000	14,965,000

For some of the countries the accounting, especially for the latest month, is preliminary and subject to revision, which may be considerable. The Mexican returns, which arrive late, are difficult to estimate, owing to their irregularity. †Conjectural.

Quebec

In Beauchastel Township, adjoining Rouyn Township of the west, one operating mine, the Aldermac, and three adjoining gold properties, the Francoeur, Arntfield, and Lake Fortune, constitute an interesting group. The 500-ton mill of Aldermac has two products, a copper concentrate which is shipped to the Noranda smelter near by, and a high-grade pyrite concentrate. Contracts have been made for the sale of a large amount of the pyrite in Chicago, and shipments are by rail to a port on Georgian Bay and thence by water to Chicago. The Aldermac shaft has recently been enlarged to three compartments with a view to permitting 1,000 tons a day of ore to be raised, the intention being to double the milling capacity to this figure in the near future.

Until recently the ore in sight at the Arntfield was confined to rather small, high-grade veins. Recently, sections up to 60 ft. in width adjoining these veins have been found to be of ore grade, and a sufficient tonnage of material of this grade to warrant the erection of a mill will probably be proven shortly.

Francoeur Gold Mines, which property covers the westward extension of the Arntfield ore zone, is sinking a shaft to a depth of 225 ft., with a view to opening a substantial shoot of ore indicated by diamond drilling. The extensive gold-bearing zone on the Francoeur holds possibilities similar to those of the Arntfield.

At the Lake Fortune, the first gold property to be opened in the gold belt of northwestern Quebec more than twenty years ago, development is to be resumed. The shoots of ore formerly determined were of high grade and small tonnage; but the present price of gold gives the property an outlook for a much larger tonnage of ore.

Manitoba

The Flin Flon mine of Hudson Bay Mining & Smelting, in preparation for the cessation of open pit mining, has extended underground development to 1,170 ft. in depth and made preparations for stoping between this and the 650-ft. level, above which all ore has been taken up to the present. The ore reserve has been fully maintained both in tonnage and in grade.

Australians Applying Geophysical Methods ... More New Companies

AN ELECTRICAL prospecting survey over leases totaling 500 acres north of the Wiluna leases, West Australia, and owned by Granites Development, has shown the existence of three shear zones. These are being tested by costeaning and diamond drilling. The areas are 3 miles north of the Wiluna company's main shaft.

Zinc Corporation, Broken Hill, has pegged a group of mining leases at the Pinnacles, near Broken Hill. A complete geological examination of the area is to be undertaken.

Four companies — Talbot Alluvials, Madam Hopkins Deep Leads, Homebush Deep Leads and Langi Logan Deep Leads—have been formed in London in recent months to develop large areas of deep leads in the Ballarat district.

Weerianna Gold Mines has been formed in Adelaide to develop a number of leases in the Roeburne district, Western Australia.

The boring on the Paringa lease, Kalgoorlie, which adjoins the old Iron Duke lease, has proved four lodes over a length of 1,200 ft., with assays that vary widely but are highly payable. An additional £70,000 is to be spent in carrying out underground development work.

New Red White and Blue, Bendigo, is considering alterations to the milling plant to give a capacity of 2,000 tons weekly. At present the capacity is only 700 tons. Metallurgical improvements are also under consideration. The company has large reserves of low-grade ore, which at today's gold price can be handled profitably.

Sons of Gwalia, of Leonora, Western Australia, recently investigated an alluvial area in the Lisle Valley, Tasmania, but did not proceed with the option.

The cyanide plant of Golden Plateau, Cracow, Queensland, is in full operation. The capacity is 2,000 tons monthly, and this will soon be reached. Golden Plateau is the most promising of several mines on the Cracow field.

Gold Mines of Australia has acquired an option over the New Morning Star mine, at Woods Point, Victoria. The reefs zigzag across a bulge in a diorite dike, and have been worked to a depth of 1,200 ft. If the option is exercised, £30,000 is to be spent on development, mainly shaft sinking and driving.

For the four weeks ended Feb. 21, Mount Morgan treated 13,130 tons, for 2,439 oz. of gold, and 50 tons of copper in flotation concentrates, marketed overseas. The flotation plant is to be expanded to treat 5,000 tons weekly.

Mount Lyell Mining & Railway, Queenstown, Tasmania, was recently forced to close down its copper mines for over fourteen days because of shortage of water.

Gold Interests to Discuss Code at Denver on May 18-19

Representatives of the gold-mining interests of the country will meet at Denver on May 18-19 to discuss provisions for a proposed code for the industry. The meeting will be held under the auspices of the Gold Mining Association of America, the president of which organization is former Senator Tasker L. Oddie, and the Colorado Mining Association. Robert S. Palmer, executive secretary of the association, is in charge of arrangements for the meeting.

The Siskiyou chapter of the Mining Association of California has appointed State Senator James M. Allen and George Milne, president of the chapter, as delegates to represent 75 producers and developers and several hundred operators from that county. Judge Frawley, of Alaska, will represent the placer interests of that territory, and another delegate will represent the lode mining men. Idaho, Washington, and Oregon have announced that they will send delegations. Carl J. Trauerman, president of the Mining Association of Montana, has wired that his State will be represented by 38 delegates, representing several hundred operators. Utah, Nevada, New Mexico, Arizona, Wyoming, and Colorado, according to reports, will be represented by delegations.

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Mexico Aids Prospectors —Mining Expands

The Ministry of National Economy has created a bureau in Mexico City to give technical aid to prospectors and small-scale miners working lands that are undeveloped or which cannot profitably be operated by large companies. Establishment of a bank to finance such operators is also being undertaken.

Arrangements are being made by Fundicion de Pinal de Amoles to reopen the Santo Domingo silver mine, near Santo Domingo, Queretaro. . . . Peñoles Mining is arranging to work silver and copper deposits in the Tlacolula and Ocotlan districts, Oaxaca. The company has shipped machinery to Torreon, Coahuila, to equip an industrial arsenic plant at its smelter there. The machinery was brought from a similar plant at Mapimi, Durango, which was closed owing to its being far from consumption centers.

Two to three carloads of gold and silver ores are being shipped weekly by the Minas Cinco de Mayo y Anexas, operating at Pilares de Teras, Sonora. . . . A daily capacity of 325 tons of gold-silver ore has been attained at the mill of the Minas del Tajo at Rosario, Sinaloa. The company is employing 560 men and is renovating the mill's sand and slime plant. . . . American interests, headed by A. L. Richards, of Ajo, Ariz., have installed a 100-ton daily capacity Fahrenwald flotation mill at their Sierra Pinta properties, Sonora.

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Dominion Recovery Stressed By Canadian Institute

Meeting at the Chateau Frontenac, in Quebec, the Canadian Institute of Mining and Metallurgy held its 35th annual convention on April 3, 4, and 5. The sessions were marked by excellent presentation of technical subjects, sociability, and good fellowship, and ample evidence that "the mineral industry leads in Dominion-wide recovery."

Human interest centered in a novel symposium on prospecting, in which one prospector after another related in simple language the story of his discovery of Dome, Noranda, Great Bear Lake, Opemiska, Cariboo Quartz Gold, and other well-known mining developments. Of special significance was the important part played by the airplane in some of the recent discoveries.

The annual banquet, attended by more than 500 members and guests, was marked by an unusual exhibition of Dominion-wide unity of the mining industry and of the cooperation of the national and provincial governments. Over a coast-to-coast radio network the Premier of Quebec and Ministers of Mines for the Dominion and the provinces spoke to the mining industry, either from the banquet table or from their respective seats of government.

Mr. S. G. Blaylock, vice-president and general manager of Consolidated Mining & Smelting Company of Canada, Trail, B. C., was elected president of the Institute for the ensuing year. Vice-Presidents were elected as follows: British Columbia, C. P. Browning; Alberta, C. E. Garnett; Manitoba and Saskatchewan, R. E. Phelan; Ontario, C. W. Drury; Quebec, W. G. McBride; Nova Scotia, J. P. Messervy.

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Rand Exploration Expands

Increased interest in the possibilities of the Far Eastern Rand and Far Western Rand has resulted in greatly extended exploratory activities in both areas.

An air survey of the Rand is to be made shortly by Geological Air Surveys, Ltd., for geological purposes. The air photographs will be available to those engaged in the mining industry.

Personal Notes·Comment·Criticism

A. Franchie, mining engineer, of Durkee, Ore., is examining gold properties in western Montana.

Wilbur H. Grant, consulting geologist, has returned to San Francisco from a professional trip to Weepah, Nev.

B. B. Hood has recently been made assistant manager of the American Potash & Chemical Corporation at Trona, Calif.

Guy C. Riddell has returned from a three months' visit to Russia, Poland, and Germany and is at the Engineers' Club, New York City.

Arnold Gustafson, recently associated with Pickands, Mather & Company, is now with the Freeport Sulphur Company, at Freeport, Tex.

Robert E. Tally, of Jerome, Ariz., has been named chairman of the Arizona commission to send an exhibit to the Century of Progress exposition.

Roy H. Elliot, consulting engineer, has returned to San Francisco after completing examination work for the New Mexico Gold Producers Corporation, Taos, N. M.

Dr. A. K. Snelgrove, a faculty member of the geology department of Princeton University, has been appointed consulting geologist to the government of Newfoundland.

C. O. G. Larcomb, a geologist of high repute in Australia, and for 27 years a lecturer on geology and mining at the Kalgoorlie School of Mines, has resigned to go into private practice.

Will H. Coghill, supervising engineer at the Rolla, Mo., station of the United States Bureau of Mines, is giving a course of lectures on ball milling at the Missouri School of Mines and Metallurgy.

Dr. Paul D. Merica, assistant to the president of the International Nickel Company, is visiting the company's properties in England. He is expected to return to the United States early in June.

D. B. McAllister, mining engineer, announces the opening of a consulting office in San Luis Potosi, S. L. P., Mexico, where he will specialize in examinations, investigations, and management.

Carl S. Elayer, formerly chief engineer of the Arizona Commercial Mining Company at Globe, has been appointed superintendent of the American Smelting & Refining Company's mine at Vanadium, N. M:

C. W. Dowsett, consulting metallurgist for Dome Mines, Porcupine, Ont., has recently achieved a consistent extraction of over 98 per cent of the gold values, a remarkable feat, as the ore was formerly considered to be of a refractory nature.

L. W. Bladon has returned from Spain to become assistant at the Bussieres mine in northern Quebec. **J. P. Norrie** has been manager of this gold property since its development was started two years ago by Treadwell-Yukon.

Downie D. Muir, Jr., manager of the intermountain division of the United States Smelting, Refining & Mining Company, has been advanced to the position of vice-president in charge of Western operations and made a member of the board of directors. Beginning May 1, Mr. Muir will make his headquarters in Boston. **E. A. Hamilton,** manager of mines, has been promoted to the position of vice-president in charge

Downie D. Muir

E. A. Hamilton

of the intermountain division with offices in Salt Lake. Mr. Muir in 1913 became superintendent of the exploration department of U.S.S.R.&M. A year later, he went to Alaska, to direct operations in the Alaska Ebner mine. In 1915, he came to Salt Lake as intermountain manager of the company's exploration department. In 1924, he became vice-president and general manager of the intermountain division.

Dr. Curtis L. Wilson, professor of metallurgy at the Montana School of Mines, addressed the April meeting of the Montana Society of Engineers, in Butte, on April 9, on "Recent Developments in Metallurgy."

Robert D. Hoffman, mining geologist, of New York, and a director of Consolidated Coppermines, recently visited California to inspect some mining properties in which he is interested, going to that State and returning to New York by airplane.

Fraser D. Reid has been appointed managing director of Casey Summit Gold Mines, in which Coniagas Mines has a substantial share interest. The company's property in the district of Patricia, Ontario, is responding splendidly to underground development.

Robert S. Merriam has been made managing engineer for the Metropolitan Mines Corporation, which has a silver-lead property in Shoshone County, Idaho. Until last December Mr. Merriam had been chief engineeer for the Callahan Lead-Zinc Company for a period of ten years.

H. D. Bailey, whose article on "Ore Genesis at Meadow Creek Mine" appeared in the April issue, is connected with the Yellow Pine Company, of Stibnite, Idaho, and not with the Yellow Pine Mining Company, at Goodsprings, Nev., as stated in the April issue.

Glenville Collins has just returned to San Francisco from conferences in New York and Boston, on mining operations in California and Arizona. He is operating the Hope Metals Company property at Winkelman, Ariz., and the John mine, near Paradise, Calif., as consulting engineer.

J. C. Houston, who is sinking a shaft to 500 ft. for Gunnar Gold Mines, in the Central Manitoba gold field, is making such good progress that a Canadian record may be established. If Mr. Houston is able to corroborate in the four levels from this shaft the results obtained by diamond drilling, Gunnar Gold will be ready for a mill.

Dr. L. H. Duschak, of 582 Market St., San Francisco, Calif., has been made administration member of the Code Authority for the quicksilver industry. Dr. Duschak is a consulting engineer on quicksilver and other metallurgical problems, a member of the American Institute of Mining and Metallurgical Engineers, Mining and Metallurgical Society of America, and the American Institute of Chemical Engineers.

A. W. Allen, of Placerville, Calif., recently visited the Orogrande mining district of Idaho. He reports that good progress is being made in the reconstruction of the National Company's mill and cyanide plant at Orogrande, under the direction of **Karl F. Peters,** for several years in South America with the Chile Exploration, Anglo-Chilean, Consolidated, and Cerro de Pasco companies.

Ray Higgins of Duluth, president of Consolidated Copper Mines, together with **Earl Hunner,** of Duluth, general manager of mines for the M. A. Hanna Company, and **Edwin Derby,** of Ish-

peming, geologist of the Cleveland Cliffs Iron Company, made an inspection trip during April to the company mines at Ely, Nev., and also visited Boulder Dam and other points of interest in the West.

S. G. Blaylock, president of the Canadian Institute of Mining and Metallurgy, has set on foot a movement to scrutinize and regulate more closely the professional conduct of members, in the interests of the profession as a whole. The first step has been to prohibit a member from reporting publicly on a mining property in which is is financially interested. Where necessary, the bylaws of the Institute will be amended to strengthen the hands of its Council.

K. S. Twitchell, mining engineer, has returned to London after visiting ancient gold mines in the Red Sea Hills, in the Sudan. He reports inspection of "The Cradle of Gold" mine, among many mines visited, in which stopes up to 1,000 ft. long and 60 ft. wide were observed. Cufic inscriptions indicate that the mine was worked between 800 and 950 A.D. Mr. Twitchell has obtained from the Saudi Arab Government an important concession for Standard Oil of California.

A. C. Richardson has been appointed to the technical staff of Battelle Memorial Institute, at Columbus, Ohio. Mr. Richardson was formerly with the United States Bureau of Mines at its Southern Experiment Station in Tuscaloosa, Ala., where he was employed in ore-dressing investigations. At Battelle Mr. Richardson will work under the direction of **Byron M. Bird,** chief concentration engineer. **Chester R. Austin,** who received his B.S. in 1928 and M.S. in 1929 in ceramic engineering at Ohio State University, has also joined the technical staff of the Institute.

Obituary

Douglass E. Harroun, mining engineer, at Berkeley, Calif., on April 11.

Mitts Quenner, 83-year-old pioneer miner, died at his home in Douglas, Ariz., on April 11.

John A. Redfern, a pioneer mining man of Hibbing, Minn., since 1895, died April 13, aged 66 years.

Harry Stanley Lyons, pioneer journalist on the Rand, war correspondent and mining man, in Johannesburg on March 15.

Nott Leete, mining engineer, who had been identified with mining interests in Mexico and Nevada for many years, died recently in Las Vegas, Nev.; aged 64.

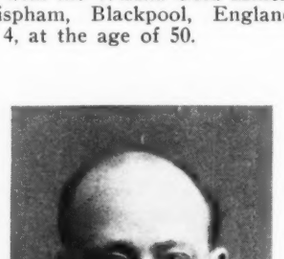
Thomas Rosser, Sr., for the past twenty years a resident of Miami, Ariz., and a former foreman at the International smelter, died in Miami on March 30 at the age of 74.

George J. Carr died recently at Helena, Mont. Mr. Carr had since 1901 been identified with gold dredging. For the past several years he was connected with the Yuba Consolidated Gold Fields.

Guy Holt, editor and publisher, a director of Whittlesey House, McGraw-Hill Book Company, died suddenly at Montville, Conn., on April 21. Mr. Hold had long been distinctively identified with the publication of books and magazines.

J. Fewson Smith, active for forty years in the Utah and Western mining industry, and head of the engineering department of the United States Smelting, Refining & Mining Company in the intermountain country, died April 8 at Kenilworth, Utah, aged 69.

William Whyte, mining engineer, associated at one time with the Mazapil Copper Company, at Concepcion del Oro, Mazapil, Zacatecas, Mexico, and lately with the Wiluna Gold Mines, died at Bispham, Blackpool, England, on April 4, at the age of 50.



Cleveland Abbe, Jr.

Cleveland Abbe, Jr., scientific editor of the volumes published by the George F. Baker Non-Resident Lectureship in Chemistry at Cornell University, died at Ithaca, N. Y., on April 18, at the age of 62. Mr. Abbe studied at Harvard University, Johns Hopkins University and the Imperial University of Vienna, and taught physiography, geology and biology at Columbia University, the College of the City of New York, and Western Maryland College. In 1920 and 1921 Mr. Abbe was a member of the editorial staff of *Engineering and Mining Journal.* He was formerly editor of "The Monthly Weather Review." His father, Professor Cleveland Abbe, an eminent meteorologist, who died in 1916, devised a weather report system at Cincinnati from which grew the present system of daily weather reports in use throughout the country.

Mexico's Immigration Laws

The Editor:

Referring to the letter of "Mining Engineer," published in your February issue, regarding immigration into Mexico, I send you a translation of an ordinance recently sent by the Mexican Immigration Bureau to all of its offices:

"From this day, you may allow entrance into the country classified as transients and for a period of one year, American citizens who wish to enter for the purpose of carrying on mining explorations or other matters pertaining to the same occupation, without having first to consult this Department. You should require in each case, as a guarantee for repatriation, a deposit not to exceed 100.00 Pesos, and this deposit may be increased up to 250.00 Pesos when interested parties wish to go further south than the states of Sonora, Chihuahua or Baja California (those states bordering the U. S.). Also, you should require a proof that interested parties be solvent and that their intentions are sincere, obtaining for this purpose letters of recommendation from banking institutions in your locality. With regard to foreigners not American citizens, proceed in the same manner, but require the maximum deposit guaranteeing repatriation, as indicated by Article 116 of the Immigration Law."

The salient part of this ordinance is that it does away with having to wait for final resolution from Mexico City, as each Immigration Office is given the power to act in each particular case. Therefore, foreign capital, and especially American, is given all facilities to enter Mexico for developing its mining industry.

E. TORRES, JR.
Nogales, Sonora, Mexico.

Editor's Note: From another source we have the following information bearing on this matter:

"It is true that the immigration laws have been amended recently, but the present laws, like the previous ones, strictly prohibit the immigration of foreigners with the object of working in Mexico. The only exceptions stipulated in the amendments are the following cases: Parties with properties in Mexico desiring to go to Mexico to live; capitalists; students, professors; artists, and technical men.

"The exception in which you are interested, which is the one concerning technical men, has been simplified in the following manner: The Immigration Office in Juarez has been authorized to allow the temporary immigration of technical men without taking the matter up with Mexico City. The interested party has to convince the Immigration Chief in Juarez with documentary proof that he is a specialist in his line; that he has been contracted by a company established in Mexico; that he is going into Mexico temporarily; and that his presence is essential for accomplishing the task for which he has been contracted.

"He has to prove his technical knowledge with diplomas or affidavits from the places he has worked, and has to show his working contract or an affidavit from the contractor. If the Immigration Office is convinced of the technical knowledge and that the applicant is the man in question, they can then extend the temporary passport for as much as six months. Before securing the passport, the applicant has to deposit, as before, $250 Mex. Cy. with the Banco de Mexico, pay his Head Tax of $22 Mex. Cy., and $2 Mex. Cy. for the passport card.

"As you can see from the above, the only advantage now is that these matters can be handled locally without taking them up with Mexico City."

BOOK REVIEWS

Advice for Students

BUILDING AN ENGINEERING CAREER. *By C. C. Williams. McGraw-Hill Book Company, 330 West 42d St., New York. Pp. 247. Price $2.*

"Building an Engineering Career," by Dean C. C. Williams of the University of Iowa, fills most admirably a long-felt want in engineering education. Written in a clear, concise, logical manner, it carries on the foundation laid by "Engineering: A Career—A Culture," the pamphlet prepared by the Engineering Foundation for high-school students into the freshman year in our schools of engineering.

The well-arranged, carefully written, accurate subject-matter covers admirably the nine specific objectives set out by the author in his preface:

1. To give a preview of the engineering profession as to its character and its relation to social organization in order to aid the student in his choice of a vocation.

2. To assist the student at the outset in adopting efficient study methods and in forming orderly mental habits, particularly with reference to technical subject-matter.

3. To indicate the quantitative and creative nature of an engineer's mode of thinking, using to this end problems that involve engineering concepts but no advanced mathematics.

4. To afford a background by means of a historical synopsis of the preceding story of engineering that will enable the student in retrospect to perceive the slow development through all previous history as compared with the tremendous acceleration of the last century and, in prospect, to glimpse the unpredictable expansion of engineering achievement destined to follow modern discoveries in physical science.

5. To conserve and cultivate as a motivating influence the student's initial interest in engineering during that disappointing period of his assignment to fundamental, although to him irrelevant, subjects, and to enable him more readily to view his course as a unified engineering project.

6. To introduce the student to the vocabulary of engineering by means of narrative rather than by technical definitions.

7. To show the student a layout view of the engineering curriculum and profession as the general plan from which he will build an engineering career.

8. To inculcate, by means of a recital of engineering triumphs, a will to achieve in study and in the profession.

9. To call attention to the ethical and cultural ideals of the profession and to the desirability of forming ethical attitudes as well as efficient mental habits.

Could we but drive an understanding of these objectives into every one of our students, fully one-tenth of our engineering educational job would be finished, and how much easier the other nine-tenths would become.

All engineering educators giving or contemplating giving an orientation course to engineering freshmen should express their thanks to Dean Williams for the first real textbook in this field. No matter how long since he graduated, every engineer can well afford to read this book and in particular Chapters II, IV, V, and XVI. The reviewer hopes that many schools will adopt it as a text and then encourage every student to re-read it yearly. J. W. BARKER.

The Great Bonanza

THE SAGA OF THE COMSTOCK LODE. *By George D. Lyman, Charles Scribner's Sons, New York. Illustrated. Pp. 399. Price $3.50.*

One of the most colorful periods in American mining history is undoubtedly that of the Comstock boom, which dates back to the eighteen-fifties and sixties. Those days have been discussed by many, but perhaps none has so captured their atmosphere as has this author, who was born in Virginia City in the early eighties and, from youth, absorbed the traditions and folklore of the Washoe district. Dr. Lyman, now a well-known physician in San Francisco, has made a thorough search of source material for his saga; this is evident from even a casual study of the forty pages of notes with which the book is documented. For the mining engineer, the volume would seem to hold more of interest than any other non-technical mining work of recent years.

White Ants

TERMITES AND TERMITE CONTROL. *A report to the Termite Investigations Committee. Editorial Board: Charles A. Kofoid, Editor-in-chief; S. F. Light, Merle Randall, W. B. Herms, A. C. Horner, and Earl E. Bowe. University of California Press, Berkeley. Pp. 768; 182 illustrations. $5.*

This volume contains the results of an elaborate investigation by a group of scientists of the University of California, the National Lumber Manufacturers Association, and other agencies interested in the subject. Investigations were supported by funds contributed by industrial and commercial organizations. The report includes a discussion of the biology of termites, chemical methods for prevention and control of termite damage, and recommended methods of building construction. An invaluable volume for those who are confronted with the practical problems of combating the ravages of termites.

Electrochemistry

HANDBUCH DER TECHNISCHEN ELEKTROCHEMIE. Part II, Vol. I. *By Victor Engelhardt. Akademische Verlagsgesellschaft m.b.H., Leipzig, Germany. Pp. 451. Price 44 Rm.*

Like the volumes already completed, this is an outstanding contribution to the literature on technical electrochemistry; it contains a wealth of well-arranged data which cannot fail to impress the reader. Electrolysis of water and chlor-alkali electrolysis are the subjects treated, the former by Dr. Pfleiderer, of I. G. Farbenindustrie, the latter by Professor Billiter and Dr. Fuchs, of Vienna.

1934 Skinner

MINING YEAR BOOK 1934. *Compiled and published by Walter E. Skinner, 15 Dowgate Hill, Cannon St., London, E.C.4. Price, 21s. 6d. post free abroad.*

The 48th annual issue of this well-known reference work contains full particulars of 1,220 of the principal mining companies of the world. On account of the revival in mining promotion in 1933, this volume includes a number of new companies, particularly those registered in South Africa. A useful feature is the numerous maps of properties of important companies. As in the past, all statements have been revised and, wherever possible, officially verified.

African Companies

KAFFIRS. *By Owen Letcher. Johannesburg, Transvaal; Mining & Industrial Magazine of Southern Africa. Pp. 200; 10s. 6d.*

This volume, the first of a series to be issued annually, contains information in readily accessible form on the properties, operations, capitalization, stock prices, dividend disbursements, and financial status of all the more important mining companies in South and East Africa, with a special section on new flotations. Although complied primarily for the benefit of shareholders and investors, it contains much statistical and other information that, because of promptness of issuance, is of general interest and value.

INDUSTRIAL PROGRESS

Novel Crusher Pitman and Toggle System

Radical Changes Made in New Jaw Breaker

In the new primary jaw crusher developed by the Pennsylvania Crusher Company, of Philadelphia, and introduced under the name of "Pennsylvania Buchanan," originality is displayed in the design of the pitman and the toggle system. This is well illustrated in detail and assembly in the accompanying drawing.

The pitman has always been a problem in large jaw crushers. It must be strong and rigid, but not of excessive weight. If it is too heavy, its eccentric movement causes too much vibration and throws the entire crusher out of balance. In the new crusher it is made of special steel shapes, cut and machined exactly and then welded to give greatest strength and rigidity with least weight.

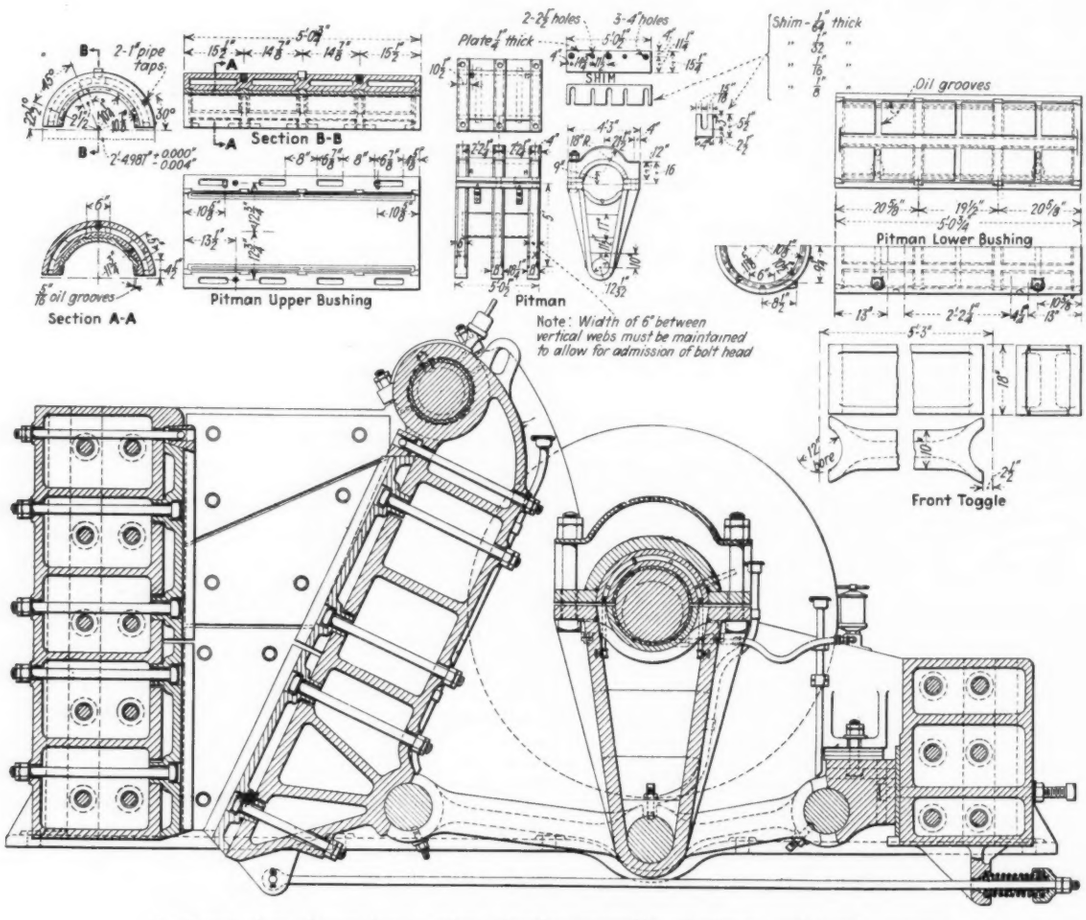
The pitman cap has a removable interchangeable water-jacketed bearing. This, together with the removable water-jacketed frame bearings, gives the crusher the feature of having all bearings replaceable, eliminating shutdowns when rebabbitting is necessary.

In design, the toggle system is entirely new. The old type of rounded toggle ends fitting into small recessed toggle bearings has always been a source of trouble, because of rapid wear and cutting of both ends and bearings, due to the high pressure developed over their relatively small surfaces.

In the new crusher, the toggle bearings have been discarded, and large steel shafts have been employed. One shaft in the pitman serves as bearing surface for both front and rear toggle, giving a straight line pull for the pitman directly in line with the eccentric shaft, whether the pitman is vertical or somewhat tipped because of shims used to take up the wear of the jaw plates. A shaft is also placed at the back of the swing jaw and in the tailpiece to serve as bearings for the front and rear toggles respectively.

The toggle ends are the reverse of the old conventional type. They are built with machined semicircular surfaces to act with the bearing shafts, with as little friction as possible, and are provided with accessible lubrication and protected from dust and grit.

For lubrication, the pitman is fitted with a manifold with flexible connections leading to two extra large reservoir cups, mounted on the rear of the side



Sectional view of new jaw crusher, showing assembly of pitman and toggle system. Above: Details of pitman and toggles

frames at convenient points for attention and refilling. The toggles are lubricated by heavy oil, fed by pipes leading to convenient places on the side frames. These pipes are fitted at the inlet with snap spring covers, effectively keeping out dust after oiling has been completed.

The frame, which is in four parts, and the swing jaw are of cast open-hearth steel annealed. They are lubricated by automatic pressure-filled grease cups having visible indicators. Eccentric shaft and jaw shaft are of forged steel.

Protection Against Dust

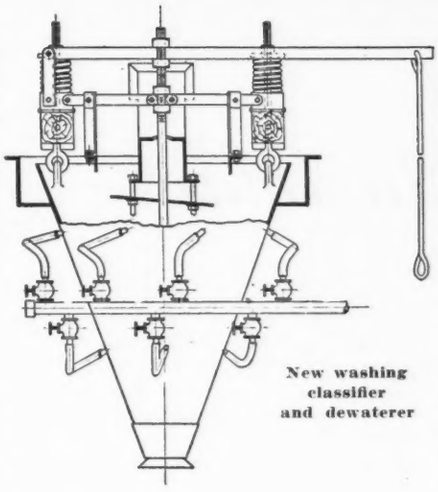
A line of improved respirators for protecting workers against inhaling lead, silica, and similar dusts, and spray mists, has been developed by the Pulmosan Safety Equipment Corporation, Brooklyn, N. Y., after experiments and tests with the aid of dust control engineers. It is called the "M" series. Among its features are: Increased filter size, direct-breathing intake and coarser-mesh wire screens to permit easier breathing; screens bound with aluminum for strength and safety; use of a gas-mask type exhaust valve, positive in action; change from elastic to all-rubber headbands, adjustable for longer wear and attached to a swivel joint that allows free movement of the head without respirator leaving the face; a new construction that prevents obstruction of wearer's vision. Goggles can be worn.

Improved Wagon Drill

For facilitating the drilling of deep holes in quarries and in general rock excavation, an improved wagon drill has been introduced by Worthington Pump & Machinery Corporation, Harrison, N. J. This machine incorporates an adjustable drill-steel centralizer, a feature which reduces the time and labor required to collar the holes. Another innovation is the leveling device which permits adjustment of the drill tower to the vertical position when the rig is set on uneven ground, thus eliminating the need for blocking up the wheels. The drilling engine can be demounted readily from its detachable feed slide and the slab back guide by removing two bolts, in no way disturbing the slab back. The unit can be had with either an air hoist or a hand winch for raising or lowering the drilling engine.

Improved Chrome Cement

A chrome-base refractory cement, made by Botfield Refractories Company, Philadelphia, is said to be unique in that its component materials will not settle in the drum or mortar box but remain in suspension indefinitely. Its base is high-grade chrome ore with a high chromic oxide and low silica content. Grain sizes are prepared and graded accurately before mixing and no change in grain sizes occurs during the mixing operation. The cement is said to be smooth and plastic, free from shortness, and workable even on refractory insulating brick which quickly absorbs moisture from bonding mortars. It develops a strong air-set soon after application. It is known as Adachrome super-cement.



New washing classifier and dewaterer

Washes, Classifies, and Dewaters

Shortcomings of the old-type cone are said to have been eliminated in a new washing classifier and dewaterer developed by Kennedy Van Saun Manufacturing & Engineering Corporation, New York. The apparatus is shown in the accompanying cut. It may be used singly or in a battery. Effective washing is accomplished by whirling nozzles, placed tangentially around the circumference of the cone at determined points, which violently rotate the material to be washed. The feed passes over a spreader plate before going into the washing zone, a central vortex being thus avoided. As a classifier the unit can be quickly adjusted to separate materials to any desired degree of fineness. The cone is supported on four springs which continuously weigh the contents, the movement of the scale beams in turn being used to open and close the discharge gate. As a dewaterer, the apparatus discharges a material suitable for belt conveyor transportation. There are no moving parts exposed to wear and no external power is required.

New Mining Cables

Three new mining cables have been announced by the General Electric Company. One, a new armored-type telephone cable, recommended for mine-telephone service where wires must be protected from sharp rocks or blows, resists damage because of the use of a galvanized-steel interlocking armor like that used on G-E type BX armored cable. The second, available in all standard sizes and types for 600-volt service, is a tellurium-compounded all-rubber mining cable, jacketed in rubber similar to the tread of an automobile tire. This is intended for such rough usage as running on and off gathering reels and dragging after electric shovels. The third is a Glyptal-cloth insulated cable. Glyptal is a synthetic resin which is unaffected by oil, withstands high temperatures, is tough and flexible and able to withstand mechanical abuse. This cable is intended for low- and medium-voltage motor leads, apparatus cable, transformer leads, leads for coils and control devices, and the like.

Self-Feed Drifter

A drifter drill embodying a novel self-feeding principle has been developed by Gardner-Denver Company, Quincy, Ill. It is said to be vibrationless and to have a self-controlled positive action. The steel is held constantly in proper striking position.

Gear and Pinion Puller

A flexible gear and pinion puller that develops a pressure of 75 to 100 tons, according to its capacity, has been developed by N. J. Smith, 2245 N. 12th St., Philadelphia. The gear or pinion is first loosened by means of a power device consisting of a screw, wedge, and rollers assembled in a housing. Pulling with 20 in. leverage on the power screw is sufficient to develop the pressure mentioned. The device is made in capacities of 35 to 300 tons. All parts are of heat-treated steel.

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Industrial Notes

Mine & Smelter Supply Company has moved its New York office from 225 Broadway to 1775 Broadway, where the Eastern business of the company will be handled by J. P. Bonardi and his associate, H. M. Jennings.

General Engineering Company, Inc., Salt Lake City, Utah, has moved its New York office to 30 Church St., E. S. Tompkins having been appointed Eastern manager.

Bulletins

Crane Engineering. Whiting Corporation, Harvey, Ill. Bulletin celebrating company's fiftieth anniversary. Pp. 8.

Savings Effected by Boiler Meters. Bailey Meter Co., Cleveland, Ohio. Bulletin 44A. Pp. 32.

Surface Condensers. Worthington Pump & Machinery Corporation, Harrison, N. J. Pp. 4.

Pennsylvania-Buchanan Steelbuilt Primary Jaw Crushers. Pennsylvania Crusher Co., Philadelphia, Pa. Bulletin 5010. Pp. 4.

Centrifugal Clutch Coupling. The Falk Corporation, Milwaukee, Wis. Bulletin 501. Pp. 4.

Telsmith-Wheeling Jaw Crushers. Smith Engineering Works, Milwaukee, Wis. Bulletin 265A. Pp. 20.

Underground Conveyors. Jeffrey Manufacturing Co., Columbus, Ohio. Catalog 570. Pp. 28.

Horizontal Compressors, Duplex Two-Stage. Gardner-Denver Co., Quincy, Ill.

Steam Generators, Electric-Heated, 2-18 Kw., Commonwealth Electric & Manufacturing Co., Boston, Mass. Bulletin 52A. Pp. 8.

Motor-Generator Sets. Allis-Chalmers Manufacturing Co., Milwaukee, Wis. Bulletin 1155. Pp. 24.

Transite Pressure Pipe. Johns-Manville, New York, Pp. 20.

Resistance Thermometers. Brown Instrument Co., Philadelphia, Pa. Catalog 9001. Pp. 32.

Conveying, Power Transmission. Link-Belt Co., Chicago, Ill. General Catalog. Pp. 1024.

"High Temperature Insulation." Johns-Manville, New York. Reprint of a lecture prepared by company's engineering department.

Classification and Ore Dressing. The Dorr Co., New York. Bulletin 2231, pp. 20.

Electric Heating Units and Devices. General Electric Co., Schenectady, N. Y. Bulletin GES-787B, pp. 52.

Market Summary—Quotations

THE APPROVAL of the Copper Code was accepted as the outstanding event of the month and—since NRA usually raises costs—both buyers and sellers became more price conscious, and quotations for major nonferrous metals advanced moderately. Except for the fact that surplus stocks are still excessive, and that actual consumptive demand, though increasing, is not up to expectations, prices for copper, lead, and zinc would undoubtedly have moved upward to a greater extent. Quite a few influential producers are opposed to marking up prices sharply under present circumstances, Code or no Code.

Silver recorded a severe break in prices, caused by heavy selling by speculators who took President Roosevelt's stand against mandatory legislation at this session of Congress very much to heart. Tin, owing partly to the exchange situation, sold above 56c. per pound during April. Though the quotation for aluminum named by the leading interest has not been changed, it is known that scattered parcels have sold at concessions. Nickel continues in active demand at unchanged prices. With gold holding at $35 per ounce, sellers of platinum seemed content to maintain the market for their product at $38 per ounce for refined metal. Now that quicksilver is close to $76 per flask, production in this country is expected to increase moderately this year.

Steel operations at the close of April stood at 55.7 per cent of capacity. This improvement naturally led to increased purchases of ferro-alloys, chrome ore, and tungsten ore, the latter scoring a sharp advance.

E.&M.J. Weighted Index Of Metal Prices

100 Is Composite of Non-Ferrous Prices for 1922-23-24

April	69.42
March	67.83
April, 1933	49.99
April, 1932	47.48
April, 1931	64.45
April, 1930	93.24

Current Prices—Miscellaneous Metals, Ores, and Non-Metallic Minerals

Quotations cover wholesale lots, prompt shipment, f.o.b. New York, unless otherwise stated.

Miscellaneous Metals

Aluminum, ingot, 99 per cent plus, lb.	23.30c.
Antimony, lb.	8.50c.
Bismuth, ton lots, lb.	$1.30
Cadmium, lb.	55.00c.
Chromium, 97 per cent grade, lb.	88.00c.
Nickel, electrolytic cathodes, lb.	35.00c.
Magnesium, 99.8 per cent, carloads, lb.	30.00c.
Palladium, troy oz.	$23.00
Platinum, troy oz.	$38.00
Quicksilver, flask of 76 lb.	$75.50@$76.00
Radium, mg. radium content	$50.00
Selenium, 99.5 per cent, lb.	$1.80
Silicon, minimum 97 per cent, spot, lb.	16.50c
Tellurium, lb.	$2.00
Thallium, 100 lb. or more, lb.	$6.50
Titanium, 96 to 98 per cent, lb.	$6.00
Zirconium, commercially pure, lb.	$7.00

Metallic Ores

Beryllium Ore, f.o.b. mines, ton	$30.00@$35.00
Chrome Ore, 45@47 per cent. c.i.f., long ton	$17.00@$18.00
Iron Ore, Lake Superior, long ton:	
Old Range, bessemer	$4.80
Mesabi, bessemer	$4.65
Old Range, non-bessemer	$4.65
Mesabi, non-bessemer	$4.50
Lead (Galena) 80 per cent, Joplin, Mo., ton	$45.00@$47.50
Manganese Ore, long ton unit:	
52@55 per cent	24c.
49@51 per cent	23c.
44@47 per cent	22c.
Molybdenum Ore, per lb. of contained MoS_2	42c.
Tungsten Ore, per unit of WO_3:	
Chinese, duty paid	$17.00@$17.50
Domestic Scheelite	$17.50@$17.75
Vanadium Ore, per lb. of contained V_2O_5	26c.
Zinc Ore, Prime, 60 per cent concentrate, Joplin, Mo.; per ton	$30.00

Metallic Compounds

Arsenious Oxide (arsenic) lb.	4c.
Cobalt Oxide, 70@71 per cent, lb.	$1.35
Copper Sulphate, 100 lb.	$3.85
Sodium Nitrate, ex vessel, 100 lb.	$1.31½
Sodium Sulphate, bulk, ton	$13.00@$15.00

Alloys

Beryllium-Copper, 12.5 per cent Be, 5! to 200 lb., lb.	$3.81
Ferrochrome, 65@70 per cent chromium, 4@6per cent carbon, lb.	10c.
Ferromanganese, 78@82 per cent, gross ton	$85.00
Ferromolybdenum, 50@60 per cent Mo, lb. of Mo contained	95c.
Ferrosilicon, 50 per cent, gross ton	$77.50
Ferrotungsten, 75@80 per cent, lb. of W contained	$1.30@$1.40

Non-Metallic Minerals

Asbestos, f.o.b. mines, ton:	
Canadian (Quebec)	
Crude No. 1	$450@
Crude No. 2	$200@$225
Spinning fibers	$90@$135
Paper stock	$32@$37
Shorts	$11@$15
Vermont	
Shingle stock	$45@
Paper stock	$35@
Cement stock	$23@
Barytes, long ton:	
Georgia, crude	$7@
Missouri, 95 per cent $BaSO_4$, 1 per cent iron	$5@
Bauxite, long ton:	
Domestic, chemical, 55@58 per cent	$6@ $7.50
Domestic, abrasive, 78@84 per cent	$12.50@$15.00
Dalmatian, 50@55 per cent	(a)$4.50@ $6.00
French, 56@59 per cent	(a)$5.50@ $6.50
China Clay, f.o.b. mines, ton:	
South Carolina and Georgia, bulk	$5.00@ $6.50
Delaware, No. 1	$14.00@
Feldspar, bulk, ton:	
Potash feldspar, 200 mesh	$15.00@$15.50
Glass-spar, 20 mesh	$10.50@
Fluorspar, f.o.b. mines, bulk, Kentucky and Illinois, 85-5 per cent, ton	$17.00@
Fuller's earth, f.o.b. Georgia or Florida, ton	$10.00@$14.00
Magnesite, per ton:	
Dead-burned, f.o.b. California	$28.00@
Dead-burned, f.o.b. Washington	$22.00@
Mica, per lb., North Carolina:	
No. 1 punch, 1½x2 in.	10@ 20c.
2x2 in.	25@ 35c.
2x3 in.	40@ 50c.
3x4 in.	70@ 80c.
4x6 in.	$1.25@ $1.50
White, ground, 70 mesh, ton	$60.00@$80.00
Ocher, Georgia, ton	$19.00@$22.50
Pyrites, Spanish, per long ton unit of S, c.i.f. Atlantic ports	(a)12@ 12½c.
Silica, water-floated, in bags, 325 mesh, ton	$16.00@$40.00
Sulphur, Texas mines, long ton	$18.00@
Talc, f.o.b. works, ton:	
New York, double air-floated, 325 mesh	$12.00@$15.00
New Jersey, mineral pulp	$9.00@$12.00
Vermont, extra white, 200 mesh	$8.5@0 $9.00
Tripoli, Missouri, ton:	
40 mesh, cream colored	$16.00@
200 mesh, cream colored	$26.00@

(a) Nominal.

Iron and Steel

Pig Iron, Valley, furnaces, gross ton:	
Bessemer	$19.00
Basic	$18.00
No. 2 Foundry	$18.50
Steel, base prices, Pittsburgh:	
Billets and Sheet bars, gross ton	$29.00
Structural shapes, 100 lb.	$1.85
Bars, 100 lb.	$1.90

Daily and Average Monthly Prices of Metals

April, 1934

United States Market

April	Electrolytic Copper—Domestic	Electrolytic Copper—(b) Export	Straits Tin—New York	Lead—New York	Lead—St. Louis	Zinc—St. Louis
2	7.775	7.875	55.600	4.00	3.90	4.300
3	7.775	7.925	55.475	4.00	3.90	4.300
4	7.775	7.975	55.275	4.00	3.90	4.300
5	8.025	8.000	55.700	4.00	3.90	4.300
6	8.025	8.025	56.650	4.00	3.90	4.325
7	8.025	8.075	56.625	4.00	3.90	4.375
9	8.025@8.150	8.125	56.300	4.00@4.10	3.90@3.95	4.375
10	8.150	8.175	55.800	4.10@4.25	3.95@4.10	4.400
11	8.275	8.150	55.750	4.25	4.10	4.400
12	8.275	8.075	55.625	4.25	4.10	4.400
13	8.275	8.175	55.500	4.25	4.10	4.400
14	8.275	8.175	55.375	4.25	4.10	4.400
16	8.275	8.125	55.000	4.25	4.10	4.400
17	8.275	8.075	55.350	4.25	4.10	4.400
18	8.275	8.050	55.300	4.25	4.10	4.350
19	8.275	8.000	55.250	4.25	4.10	4.325@4.350
20	8.275	8.000	56.000	4.25	4.10	4.350
21	8.275	8.025	56.000	4.25	4.10	4.350
23	8.275	8.025	55.875	4.25	4.10	4.375@4.400
24	8.275	8.050	55.825	4.25	4.10	4.375@4.400
25	8.275	8.100	55.500	4.25	4.10	4.400
26	8.275(a)	8.075	55.375	4.25	4.10	4.400
27	8.275(a)	8.025	55.000	4.25	4.10	4.400
28	8.275(a)	8.025	55.100	4.25	4.10	4.400
30	8.275(a)	8.000	55.300	4.25	4.10	4.400
Av. for month	8.173	8.053	55.622	4.179	4.042	4.370
Averages for Week						
4	7.775	7.888	55.383	4.000	3.900	4.300
11	8.098	8.092	56.138	4.079	3.958	4.363
18	8.275	8.113	55.358	4.250	4.100	4.392
25	8.275	8.033	55.742	4.250	4.100	4.369
Calendar Week Averages						
7	7.900	7.979	55.888	4.000	3.900	4.317
14	8.223	8.146	55.725	4.204	4.058	4.396
21	8.275	8.046	55.483	4.250	4.100	4.365
28	8.275	8.050	55.446	4.250	4.100	4.396

(a) Blue Eagle copper. Copper not offered for sale for domestic consumption under the code was quoted as follows: April 26th, 8.050c.; April 27th, 8.000c.; April 28th, 8.025c.; April 30th, 8.025c., f.o.b. refinery.

(b) Includes sales of domestic copper in foreign markets.

Silver, Gold, and Sterling Exchange New York and London

April	Sterling Exchange—"Checks"	Sterling Exchange—"90-day Demand"	Silver—(a) New York	Silver—London	Gold—London	Gold—(b) United States
2	5.14000	5.14250	46.0000	Holiday		$35.00
3	5.15750	5.16000	46.1250	20.0000	135s 2 d	35.00
4	5.17000	5.17375	45.8750	19.8750	134s 3 d	35.00
5	5.15000	5.15250	46.2500	20.0000	134s 8½d	35.00
6	5.15125	5.15250	46.1250	20.0000	135s 1 d	35.00
7	5.17250	5.17375	46.2500	19.9375	134s 7 d	35.00
9	5.17250	5.17375	46.5000	19.9375	134s 4 d	35.00
10	5.16250	5.16500	46.7500	20.2500	134s 6 d	35.00
11	5.16250	5.16375	46.7500	20.2500	134s 10½d	35.00
12	5.16125	5.16250	46.3750	20.1875	134s 10 d	35.00
13	5.14875	5.14875	46.0000	20.1875	134s 9 d	35.00
14	5.15375	5.15375	46.3750	20.1875	134s 11½d	35.00
16	5.15500	5.15500	45.5000	20.2500	134s 10½d	35.00
17	5.15000	5.15125	45.1250	19.7500	134s 8½d	35.00
18	5.13250	5.13250	45.2500	20.1875	135s 4 d	35.00
19	5.13750	5.13750	45.1250	19.8750	135s 3 d	35.00
20	5.16625	5.16875	45.5000	19.8750	135s 2½d	35.00
21	5.16375	5.16625	45.0000	19.6875	135s 8 d	35.00
23	5.14750	5.15000	44.7500	19.8750	135s 7½d	35.00
24	5.14750	5.15000	43.7500	19.3125	135s 11 d	35.00
25	5.14000	5.14250	42.5000	18.7500	135s 6½d	35.00
26	5.13250	5.13500	42.5000	18.7500	135s 7 d	35.00
27	5.13750	5.13875	43.0000	18.7500	135s 11 d	35.00
28	5.15000	5.15250	43.3750	19.0625	135s 9 d	35.00
30	5.14000	5.14250	42.7500	18.8125	135s 8 d	35.00
Av. for month	5.15210	.....	45.180	19.740	.....	35.00
Averages for Week						
4	5.14292	.....	45.750	.....	.....	.....
11	5.16188	.....	46.438	.....	.....	.....
18	5.15021	.....	45.771	.....	.....	.....
25	5.15042	.....	44.438	.....	.....	.....
..	.....	.....	.....	.....	.....	.....

Calendar week averages: New York Silver April 7, 46.104; April 14, 46.458; April 21, 45.250; April 28, 43.313.

(a) Silver not eligible for sale to the U. S. Government. Under Executive order issued Dec. 31, 1933; the U. S. Government price on newly mined domestic silver was established at 64½c. per troy ounce.

(b) U. S. Treasury's gold price.

London Market

April	Copper—Standard—Spot	Copper—Standard—3M	Copper—Electrolytic Bid	Tin—Spot	Tin—3M	Lead—Spot	Lead—3M	Zinc—Spot	Zinc—3M
2					Holiday				
3	32.3750	32.6250	35.5000	237.2500	236.6250	11.5000	11.8125	14.8750	15.1875
4	32.1875	32.5000	35.5000	235.2500	235.0000	11.2500	11.6250	14.6875	15.0625
5	32.8750	33.1250	35.7500	238.5000	238.0000	11.5625	11.9375	14.8750	15.2500
6	33.4375	33.6875	36.2500	243.7500	242.3750	11.5000	11.8750	15.0000	15.3750
9	33.3750	33.7500	36.2500	241.2500	239.7500	11.3750	11.7500	14.8750	15.2500
10	33.4375	33.7500	36.5000	240.5000	239.2500	11.5000	11.8125	14.8125	15.1875
11	33.3125	33.5625	36.6250	238.7500	237.3750	11.5625	11.8750	14.8125	15.2500
12	33.3750	33.5625	36.5000	238.8750	237.2500	11.5625	11.8750	14.8750	15.2500
13	33.3125	33.5625	36.2500	238.6250	237.0000	11.5625	11.8750	14.9375	15.2500
16	33.0000	33.2500	36.0000	236.6250	235.5000	11.5625	11.8125	14.8750	15.1250
17	33.0000	33.1875	36.0000	238.2500	236.7500	11.5000	11.7500	15.0625	15.3125
18	33.0000	33.1875	36.1250	239.2500	237.5000	11.5625	11.8125	15.1250	15.3125
19	32.7500	32.9375	35.7500	238.6250	237.3750	11.6250	11.8125	15.0000	15.1875
20	32.5625	32.8125	35.5000	239.5000	237.7500	11.5000	11.7500	14.8750	15.1250
23	32.8750	33.1250	35.7500	240.8750	238.5000	11.5625	11.8125	14.9375	15.1875
24	33.1250	33.3750	36.2500	240.5000	238.1250	11.5625	11.8125	14.9375	15.1875
25	33.2500	33.4375	36.2500	240.6250	238.1250	11.5000	11.7500	15.0000	15.2500
26	33.1875	33.4375	36.2500	240.2500	237.7500	11.5000	11.7500	14.9375	15.1250
27	32.8125	33.0625	36.0000	237.7500	235.5000	11.3750	11.6875	14.8750	15.0625
30	32.8750	33.0625	35.7500	238.6250	235.7500	11.3750	11.6875	14.9375	15.0625
Av. for month	33.006	.....	36.038	239.181	.....	11.500	11.794	14.916	15.200

Correction—Three-months lead, London, March 1, was £11, 15s. This changes the average for three-months lead for March to £11.842.

The United States quotations are our appraisal of the major markets for domestic consumption based on sales reported by producers and agencies. They are reduced to the basis of cash, New York or St. Louis, as noted. All prices of domestic class are in cents per pound.

Copper, lead and zinc quotations are based on sales for both prompt and future deliveries; tin quotations are for prompt delivery only.

Quotations for zinc are for ordinary Prime Western brands. Zinc in New York is now quoted as 0.35c. per pound above St. Louis; this being the freight differential. Contract prices for High-Grade Zinc delivered in the East and Middle West usually command a pre-

Silver and Sterling Exchange

	New York		London Spot		Sterling Exchange	
	1933	1934	1933	1934	1933	1934
January	25.400	44.188	16.883	19.382	336.060	504.644
February	26.074	45.233	16.885	20.073	342.114	503.085
March	27.928	45.875	17.588	20.278	343.138	509.259
April	30.730	45.180	18.440	19.740	357.565	515.210
May	34.072		19.046		393.106	
June	35.663		19.078		413.216	
July	37.630		18.341		464.760	
August	36.074		17.877		449.944	
September	38.440		18.272		466.240	
October	38.190		18.221		466.380	
November	42.974		18.428		514.573	
December	43.550		18.674		511.260	
Year	34.727		18.144		421.530	

New York quotations for silver not eligible for sale to U. S. Government, cents per ounce troy, 999 fine. London, pence per ounce, sterling silver, 925 fine. Sterling exchange in cents.

Copper

	F.O.B. Refinery — Electrolytic — Domestic		Export	London Spot — Standard		Electrolytic	
	1933	1934	1934	1933	1934	1933	1934
January	4.775	7.890	7.831	28.557	32.560	33.244	35.614
February	4.775	7.777	7.844	28.481	33.072	32 556	35.969
March	5.011	7.775	7.837	28.179	32.497	32.370	35.512
April	5.395	8.173	8.053	29.576	33.006	33.681	36.038
May	6.698			34.071		38.163	
June	7.773			36.759		41.000	
July	8.635			37.917		41.524	
August	8.768			36.071		40.227	
September	8.753			35.122		38.339	
October	7.950			33.656		36.977	
November	7.881			30.588		33.898	
December	7.885			31.306		34.329	
Year	7.025			32.524		36.359	

New York quotations, cents per pound. London, pounds sterling per long ton.

Lead

	New York		St. Louis		London			
	1933	1934	1933	1934	1933 Spot	1933 3 Mos.	1934 Spot	1934 3 Mos.
January	3.000	4.000	2.875	3.900	10.458	10.833	11.304	11.517
February	3.000	4.000	2.875	3.900	10.431	10.719	11.634	11.913
March	3.146	4.000	3.021	3.900	10.609	10.821	11.545(a)	11.842
April	3.260	4.179	3.135	4.042	10.872	11.122	11.500	11.794
May	3.654		3.525		12.095	12.372		
June	4.173		4.023		13.280	13.571		
July	4.452		4.303		13.411	13.613		
August	4.500		4.350		12.182	12.457		
September	4.500		4.350		11.932	12.229		
October	4.313		4.176		11.804	12.102		
November	4.288		4.146		11.537	11.778		
December	4.141		4.042		11.431	11.658		
Year	3.869		3.735		11.670	11.940		

New York and St. Louis quotations, cents per pound. London, pounds sterling per long ton.
(a) Correction.

Tin

	New York		London	
	1933	1934	1933	1934
	Straits		Standard, Spot	
January	22.692	51.891	145.708	226.631
February	23.500	51.668	148.544	226.731
March	24.221	53.838	149.120	233.863
April	27.136	55.622	157.944	239.181
May	36.051		186.207	
June	44.097		219.964	
July	46.356		216.673	
August	44.794		215.210	
September	46.665		216.893	
October	47.858		223.455	
November	53.011		226.722	
December	52.936		227.678	
Year	39.110		194.510	

New York quotations, cents per pound. London, pounds sterling per long ton.

Zinc

	St. Louis		London			
	1933	1934	1933 Spot	1933 3 Mos.	1934 Spot	1934 3 Mos.
January	3.018	4.271	14.381	14.595	14.688	14.943
February	2.666	4.384	13.866	14.119	14.844	15.125
March	2.987	4.368	14.647	14.674	14.735	15.033
April	3.298	4.370	14.951	15.208	14.916	15.200
May	3.805		15.505	15.660		
June	4.348		16.988	16.774		
July	4.878		17.795	17.789		
August	4.916		16.869	17.031		
September	4.699		16.810	17.042		
October	4.748		16.310	16.599		
November	4.520		15.048	15.349		
December	4.461		14.826	15.059		
Year	4.029		15.666	15.825		

St. Louis quotations, cents per pound. London, pounds sterling per long ton.

Cadmium and Aluminum

	Cadmium		Aluminum	
	1933	1934	1933	1934
January	55.000	55.000	23.300	23.300
February	55.000	55.000	23.300	23.300
March	55.000	55.000	23.300	23.300
April	55.000	55.000	23.300	23.300
May	55.000		23.300	
June	55.000		23.300	
July	55.000		23.300	
August	55.000		23.300	
September	55.000		23.300	
October	55.000		23.300	
November	55.000		23.300	
December	55.000		23.300	
Year	55.000		23.300	

Aluminum in cents per pound, 99 per cent grade.
Cadmium, cents per pound.

Antimony, Quicksilver, and Platinum

	Antimony (a) New York		Quicksilver (b) New York		Platinum (c) New York	
	1933	1934	1933	1934	1933	1934
January	5.722	7.198	48.500	67.538	26.480	38.000
February	5.738	7.172	48.614	72.011	24.000	38.000
March	5.901	7.545	52.676	75.472	24.667	38.000
April	5.876	7.918	54.580	75.930	26.800	38.000
May	6.264		56.500		28.500	
June	6.500		60.038		30.000	
July	7.262		62.900		32.320	
August	6.986		63.500		33.000	
September	6.880		64.580		34.560	
October	6.843		66.500		36.000	
November	7.113		66.000		37.583	
December	7.250		66.330		38.000	
Year	6.528		59.227		30.993	

(a) Antimony quotations in cents per pound, for ordinary brands. (b) Quicksilver in dollars per flask of 76 lb. (c) Platinum in dollars per ounce troy.

Pig Iron

	Bessemer		Basic		No. 2 Foundry	
	1933	1934	1933	1934	1933	1934
January	14.50	18.00	14.00	17.00	14.50	17.50
February	14.50	18.00	14.00	17.00	14.50	17.50
March	14.50	18.00	14.00	17.00	14.50	17.50
April	14.50	18.48	14.00	17.48	14.50	17.98
May	15.42		14.42		14.92	
June	16.00		15.00		15.50	
July	16.50		15.50		16.00	
August	17.00		16.00		16.50	
September	18 00		17.00		17.50	
October	18.00		17.00		17.50	
November	18.00		17.00		17.50	
December	18.00		17.00		17.50	
Year	16.24		15.41		15.91	

Iron in dollars per long ton. F.o.b. Mahoning and Shenango Valley furnaces

mium of 1c. over Prime Western zinc.

Quotations for lead reflect prices obtained for common lead, and do not include grades on which a premium is asked.

London prices for lead and zinc are the official prices for the first session of the London Metal Exchange; prices for copper and tin are the official closing buyers' prices. All are in pounds sterling per long ton (2,240 lb.).

New York silver quotations are as reported by Handy & Harman and are in cents per troy ounce of silver, 999 fine. London silver quotations are in pence per troy ounce of bar silver, 925 fine. Sterling prices represent noon market demand.